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Modified Method 5 Train and Source Assessment Sampling System Operator's Manual

Little (Arthur D.), Inc., Cambridge, MA

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Research Triangle Park, NC

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MODIFIED METHOD 5 TRAIN
AND
SOURCE ASSESSMENT SAMPLING SYSTEM
OPERATOR'S MANUAL

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EPA Contract 68-02-3627, Task 16

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16. ABSTRACT The report is a detailed guide for using two devices to sample stack gas effluents from hazardous waste incinerators. These two devices--the Modified Method 5 (MM5) train and the Source Assessment Sampling System (SASS) train--have been identified as the sampling devices to be used in assessing the Destruction and Removal Efficiency (DRE) of Principal Organic Hazardous Compounds (POHCs) by hazardous waste incinerators. Step-by-step procedures for cleaning, assembling, calibrating, using, and recovering samples from each device are detailed. Guidelines for the reduction and presentation of data are included.

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Sampling		Stationary Sources	14B	
Flue Gases		Hazardous Waste	21B	
Incinerators		MM5 Train		
Waste Treatment		SASS Train		
Toxicity			06T	

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ABSTRACT

The user's guide is a "start-to-finish" handbook for the cleaning of, assembly of, calibration of, use of and sample recovery from each sampling device. Sampling approaches and methodologies are integral parts of the descriptions and instructions, and guidelines for the reduction and presentation of data are included. Also incorporated into each segment of the manual are the quality assurance/quality control procedures needed to maintain the integrity of each sample from the time it is collected in the field until the time it is delivered to the analyst in the laboratory. The manual does not provide recommendations or suggestions for analysis protocols, as these are developed for each individual program based on procedures specified in other manuals.

This manual is divided into 3 parts, the first being an overview and comparison of the sampling trains. Design parameters are described to assist test program personnel in deciding which of the sampling systems is best suited for their program needs. The second and third parts of the manual outline the step-by-step procedures for use of the Modified Method 5 (MM5) Train and Source Assessment Sampling System (SASS), respectively.

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I. Overview and Comparison of the MM5 Train and SASS

1. Modified Method 5 (MM5) Train

The system design of the MM5 Train is adapted from units that are typically used for EPA Method 5 (1) sampling. The modification to the basic system is the addition of a "sorbent" module, containing a porous polymeric resin (XAD-2®)+ designed to efficiently trap vapor phase organic compounds with boiling points 100°C (212°F). The MM5 Train typically samples 3 dscm (100 dscf) during a four-hour sampling period, operating at a flow rate of 0.015 dscmm (0.5 dscfm). The use of the MM5 Train as a comprehensive sampling system has been increasing because of its inert construction and adaptability to traversing for representative particulate sampling. All surfaces that contact the sample, except the probe tip and probes greater than 2.1 m (7 ft) in length, are glass or Teflon®*, or other inert material. Traversing may be accomplished with the train as a single unit, or the heated filter (cyclone) compartment can be isolated from the sorbent module section by an appropriate length of heated flexible line. The probe and filter (cyclone) section together can be suspended from a traversing monorail or placed upon rollers, while the sorbent module and impinger train remain stationary, to minimize the possibility of breakage of the majority of the glass components.

The major advantage of this system is that particulate loading concentration data can be obtained according to EPA Method 5 (2); in addition, a representative sample of organic material is collected upon which quantitative determinations or organic material may be made. The MM5 Train is easily constructed through addition of the glass sorbent module to existing EPA Method 5 (1) hardware.

Two drawbacks to this system are: (1) the collection of sufficient sample for establishing a "four-nines" (99.99%) DRE is long (typically 4-6 hours) if the concentration of the Principal Organic Hazardous Compound (POHC) of interest is less than two percent in the fuel and (2) particle-sizing data are not obtained using the MM5 Train.

2. The Source Assessment Sampling System (SASS)

The SASS typically samples 30 dscm (1000 dscf) during a four-hour sampling period; the system is designed to operate at a flowrate of

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*Teflon® is a registered trademark of the E.I. du Pont deNemours and Co., Inc. Wilmington, DE 19898

+XAD-2® is a registered trademark of the Rohm and Haas Co., Inc., Philadelphia, PA 19105.

0.113 scmm (4.0 scfm). This train is appropriate whenever a large sample (>10 scm) is required to insure adequate detection limits of particulate and organic material. It also differs from the MM5 Train in that size fractionation is possible using three cyclones and a filter that divide the sample into 4 nominal ranges: >10 um, 3 to 10 um, 1 to 3 um and 1 um.

This train is not designed, however, for traversing a stack; the stack to be sampled is velocity-traversed to locate a point (or points) of average gas stream velocity, preferably near the center of the duct. From preliminary determinations of the gas stream moisture content, temperature and average cross-sectional velocity, the size of the nozzle and the flowrate that will result in sampling at near-isokinetic conditions are calculated. The gas stream is then sampled at this constant flowrate at one or more predetermined points (of average velocity). The SASS sample is, therefore, less amenable to compliance determination of concentrations because representative sampling conditions cannot be guaranteed.

Another drawback of this sampling system is the material of construction; the majority of the SASS components are 316 stainless steel, are subject to corrosion by acidic gases, and are more likely to interact with the sample stream. A corrosion-resistant organic sorbent module has been designed and fabricated. A report of this work appears as Appendix D; however, no commercially available flow-calibrated cyclones exist for use with the SASS.

3. Comparison of the MMS Train and SASS Characteristics

The functional characteristics of each sampling train are presented in Table 1.

TABLE 1. COMPARISON OF MM5 TRAIN/SASS CHARACTERISTICS

Characteristic	MM5 Train	SASS
Inert materials of construction	Yes	No*
Percent isokinecity achievable	90-110	70-150**
Typically used to traverse	Yes	No
Particle-sizing of sample	No	Yes
Sample size over a 4-6 hour period (dscm)	3	30
Sampling flowrate (dscmm)	0.02-0.03	0.09-0.14

*Comparable to the MM5 Train in this category if the experimental glass components described in Appendix D are used in place of the 316 stainless steel components supplied with the SASS.

**Assuming reasonably uniform, non-stratified flow.

Reference

1. Code of Federal Regulations, Title 40, Part 60, Appendix A, Methods 1-5.

II. Modified Method 5 Train: Collection Procedure for Particulate and Semi-Volatile Organic Emissions from Industrial Sources.

1. Principle and Applicability.

1.1 Principle.

Gaseous and particulate pollutants are withdrawn from an emission source at an isokinetic sampling rate and are collected in a multicomponent sampling train. Principle components of the train include a high efficiency glass or quartz fiber filter and a packed bed of porous polymeric adsorbent resin. The filter is used to collect particulate material, and the porous polymeric resin adsorbs semi-volatile organic species.

Comprehensive chemical analyses of the collected sample are conducted to determine the concentration and identity of the organic materials. Additionally, gravimetric determinations are conducted to determine particulate loading.

1.2 Applicability.

This method is applicable to the determination of the Destruction and Removal Efficiency (DRE) of semi-volatile Principal Organic Hazardous Compounds (POHC's) from incineration systems (1). This method also may be used to determine particulate emission rates from stationary sources per U.S. EPA Method 5 (2).

2. Apparatus.

2.1 Sampling Train.

A schematic of the sampling train used in this method is shown in Figure 1. This sampling train configuration is adapted from EPA Method 5 (2) procedures and as such, the majority of the equipment required is identical to that used in EPA Method 5 (2) determinations. The new component required is the organic module, which is used to collect semi-volatile organic materials that pass through the glass or quartz fiber filter in the gas phase.

Construction details for the basic train components are given as part of EPA Method 5 (2) in the report by Robert M. Martin (3); commercial models of this equipment are also available. Specifications for the organic module are provided in the following subsections. In addition, the following subsections list changes to the basic system described by Martin, and identify allowable train modifications.

Basic operating and maintenance procedures for the sampling train are described by Jerome J. Rom (4). As correct usage is important in obtaining valid results, all users should refer to this reference and adopt the operating and maintenance procedures outlined therein,

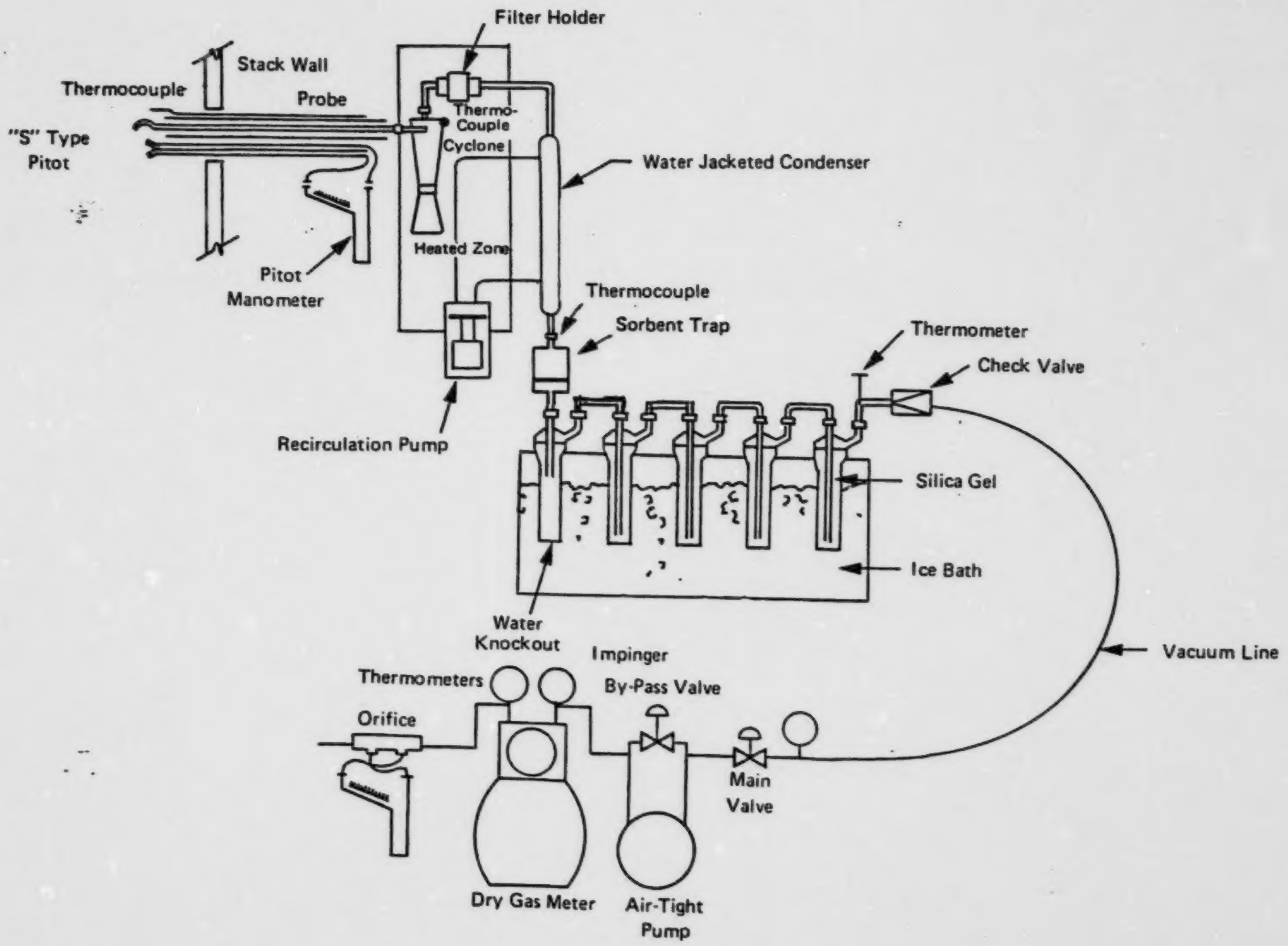
Filter Holder
Stack Wall
Thermocouple
Probe
"S" Type Pitot
Thermo-Couple
Cyclone
Water Jacketed Condenser
Heated Zone
Pitot Manometer
Thermocouple
Sorbent Trap
Thermometer
Check Valve
Recirculation Pump
Silica Gel
Ice Bath
Water Knockout
Impinger
Vacuum Line
Thermometers
By-Pass Valve
Orifice
Main Valve
Dry Gas Meter
Air-Tight Pump

Figure 1: MM5 Train schematic diagram

unless otherwise specified. The sampling train consists of the components described in the following paragraphs.

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be 30° and the taper shall be on the outside to preserve a constant inside diameter (ID). The probe nozzle shall be the button-hook or elbow design, unless otherwise necessary for a special application. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other materials of construction may be considered for particular applications.

A range of nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm (1/8 to 1/2 in.) inside diameter. If higher volume sampling trains are used, nozzles with ID's increasing in increments of 0.16 cm (1/16 in) can be procured. Each nozzle shall be calibrated according to the procedures outlined in Section 4.

2.1.2 Probe Liner. Borosilicate glass or quartz tubing with a heating system capable of maintaining a gas temperature of 120 ± 14°C (248 ± 25°F), or such other temperature appropriate for a particular application. (The tester may opt to operate the equipment at a temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not usually monitored during sampling, probes constructed according to Martin (3) and utilizing the calibration curves of Rom (4) (or calibrated according to the procedure outlined in Rom) are considered acceptable.

Either borosilicate glass or quartz probe liners may be used for stack temperatures up to about 480°C (900°F). Quartz liners shall be used for temperatures between 480 and 900°C (900 and 1,650°F) water-cooling of the stainless steel sheath is necessary, however, at temperatures approaching and exceeding 500°C.

2.1.3 Pitot Tube. Type S, as described in Section 2.1 of EPA Method 2 (2) or other appropriate (5) device. The pitot tube shall be attached to the probe to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see EPA Method 2 (2), Figure 2-6b) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of EPA Method 2 (2).

2.1.4 Differential Pressure Gauge. Inclined manometer or equivalent device (two), as described in Section 2.2 of EPA Method 2 (2). One manometer shall be used for velocity head (ΔP) readings, and the other for orifice differential pressure (ΔH) readings.

2.1.5 Filter Holder. Borosilicate glass, with a glass frit filter support and a sealing gasket. The sealing gasket should be made of materials which will not introduce organic material into the gas stream at the temperature at which the filter holder will be maintained. The filter holder housing and the frit filter support may be constructed of other materials (e.g., stainless steel, Teflon) when appropriate. The holder design shall provide a positive seal against leakage at any point along the filter circumference. The filter holder shall be attached immediately to the outlet of the cyclone or cyclone bypass.

2.1.6 Filter Heating System. Any heating system capable of maintaining a temperature of 120 ± 14°C (248 ± 25°F) in the vicinity of the filter holder during sampling; other temperatures may be appropriate for particular applications.

Alternatively, the tester may opt to operate the equipment at a temperature lower than that specified. A temperature gauge capable of measuring temperature to within 3°C (5.4°F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling. Heating systems other than the one shown in Martin (3) may be used, provided that this specification is met.

2.1.7 Organic Module. A unit consisting of three sections including a gas conditioning section, a sorbent trap and a condensate knockout trap. The gas conditioning system shall be capable of conditioning the gas leaving the back half of the filter holder to a temperature not exceeding 21°C (70°F). The sorbent trap shall be sized to contain approximately 40 grams of porous polymeric resin (Rohm and Haas XAD-2® or equivalent). The most commonly used coolant is ice water from the impinger ice water bath constantly circulated through the outer jacket using rubber or plastic tubing and a peristaltic pump. The module should be outfitted with a glass well or depression, appropriately sized to accommodate a small thermocouple in the far end of the trap for monitoring the gas exit temperature. The condensate knockout trap shall be of sufficient size to collect the condensate following gas conditioning. The organic module components shall be oriented to direct the flow of condensate formed vertically downward from the conditioning section, through the adsorbent medium, and into the condensate knockout trap. The knockout trap is usually similar in appearance to an empty impinger directly underneath the sorbent module; it may be oversized and should have a shortened center stem to collect a large volume of condensate without overflowing into the impinger train. All surfaces of the organic module wetted by the gas sample shall be fabricated of borosilicate glass, Teflon® or other inert materials.

Complete versions of the complete organic module are not available, but may be assembled from commercially available laboratory glassware and a custom-fabricated sorbent trap. Details of three acceptable designs are shown in Figures 2, 3 (6), and 4. (The thermocouple well is shown only in Figure 2.).

2.1.8 Impinger Train. The following system shall be used to determine the stack gas moisture content; four 500 mL impingers connected in series with leak-free ground glass or any leak-free non-contaminating fittings. The first, third and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip

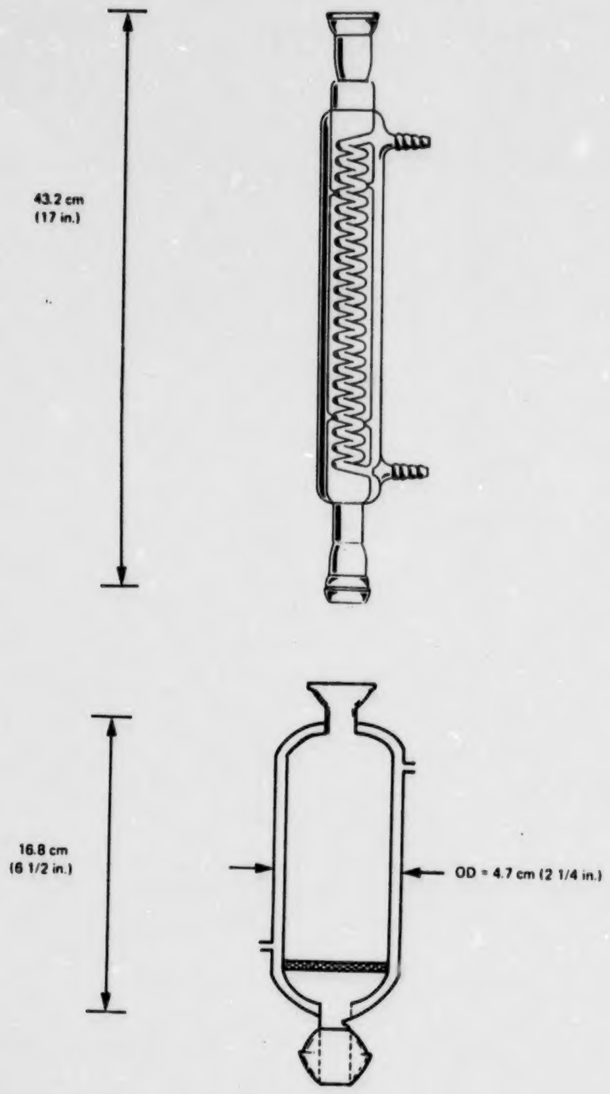
43.2 cm
(17 in.)
16.8 cm
(6 1/2 in.)
OD = 4.7 cm (2 1/4 in.)

Figure 2: Acceptable sorbent module design #1

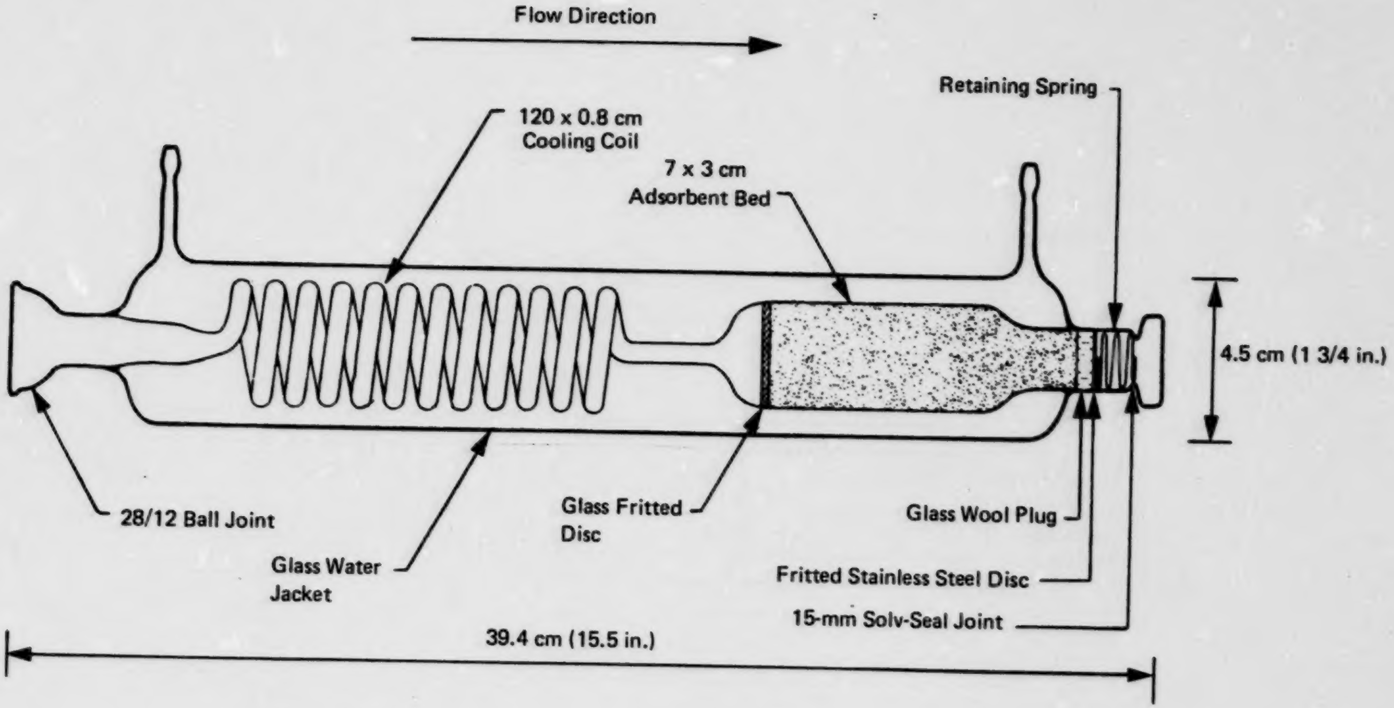
Flow Direction
Retaining Spring
120 x 0.8 cm Cooling Coil
7 x 3 cm Adsorbent Bed
4.5 cm (1 3/4 in.)
28/12 Ball Joint
Glass Water Jacket
Glass Fritted Disc
Glass Wool Plug
Fritted Stainless Steel Disc
15-mm Solv-Seal Joint
39.4 cm (15.5 in.)

Figure 3. Acceptable sorbent module design #2

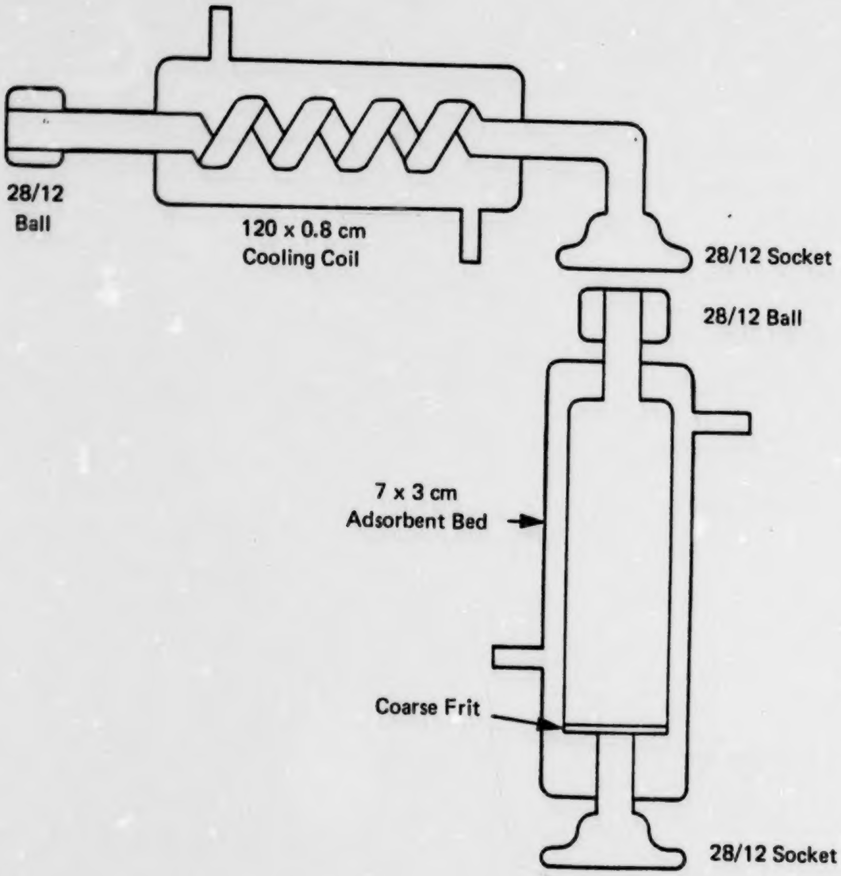
28/12
Ball
120 x 0.8 cm
Cooling Coil
28/12 Socket
28/12 Ball
7 x 3 cm
Adsorbent Bed
Coarse Frit
28/12 Socket

Figure 4. Acceptable sorbent module design #3
(dimensions similar to desing #2)

with 1.3 cm (½ in.) ID glass tube extending to about 1.3 cm. (½ in) from the bottom of the outer cylinder. The second impinger shall be of the Greenburg-Smith design with the standard tip. The first and second impingers shall contain known quantities of water or appropriate trapping solution, the third shall be empty, and the fourth shall contain a known weight of silica gel or equivalent desiccant. A thermometer, capable of measuring temperature to within 1°C (2°F) shall be placed at the outlet of the fourth impinger for monitoring the gas temperature at the impinger train exit.

Alternatively, any system that cools the sample gas stream and allows measurement of the water and condensed moisture to within 1 mL or 1 g may be used. To measure the water and condensed moisture gravimetrically, the sample gas stream must be passed through a tared silica gel (or equivalent) trap with exit gases kept below 20°C (68°F), and the weight gain of the desiccant determined.

2.1.9 Metering System. The necessary components are a vacuum gauge, a leak-free pump, thermometers capable of measuring temperature to within 3°C (5.4°F), and a dry gas meter capable of measuring volume to within 1 percent, as shown in Figure 1. At a minimum, the pump should be capable of 4 cfm free flow and the dry gas meter should have a recording capacity of 0-999.9 cubic feet with a resolution of 0.005 cubic feet. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 1 percent may be used. The metering system must be used in conjunction with a pitot tube to enable checks of isokinetic sampling rates.

Sampling trains utilizing metering systems designed for higher flow rates than those described by Martin (3) or Rom (4) may be used provided that the specifications of this method are met.

2.1.10 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm. Hg (0.5 in. Hg). The barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in Hg) per 30 m. (100 ft.) elevation increase or vice versa for elevation decrease.

2.1.11 Crushed Ice. Commercially available. Quantities ranging from 10-50 lb. may be necessary during a sampling run, depending upon ambient air temperatures.

2.1.12 Lubricant. Solvent-insoluble, heat stable silicone lubricant. Silicone lubricant is not to be used upstream of organic module and amounts used on components located downstream of organic module shall be minimal. Lubricant usage downstream of the organic module is generally not necessary if ground glass joints are properly cleaned and assembled, or if screw-on connectors are used.

2.1.13 Glass wool. Used to plug the unfritted end of the sorbent module. The glass wool fiber should be solvent-extracted with methylene chloride in a Soxhlet extractor for 24 hours and air-dried prior to use.

2.1.14 Gas Density Determination Equipment. The fixed gas samples for determining the stack gas density during the MM5 run is taken using an integrated gas sampling train. The gas sample is bled through a nonreactive probe, and an air-cooled condenser (or equivalent) removes excess moisture from the gas stream and cools the hot gas to ambient temperatures. The sampling flowrate is measured with a flow rate meter and controlled by a needle valve. The sample is collected in a leak-free bag and analyzed with an ORSAT apparatus. Detailed specifications may be found in EPA Method 3 (2).

2.1.15 Calibration/Field Preparation Record. For documenting and recording calibrations and preparation procedures (i.e. filter and silica gel tare weights, clean XAD-2® quality assurance/quality control check results, dry gas meter and thermocouple calibrations, etc.), a permanently-bound laboratory notebook is required, in which duplicate copies of the data may be made as it is being recorded. The duplicate copies should be detachable and stored separately in the test program archives.

2.2 Sample Collection Media.

2.2.1 Filters. Glass or quartz fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (0.5 percent penetration) for 0.3 um dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM standard method D 2986-71 (7). Test data from the supplier's quality control program are sufficient for this purpose. In sources containing SO_2 or SO_3, the filter material must be of a type that is unreactive to these acid gases. Refer to Citation 8 in Section 6 for recommendation of appropriate filter material (8).

2.2.2 Adsorbent Resin. Porous polymeric resin, XAD-2®, typically used and recommended. The resin must be cleaned prior to use, according to the procedure outlined in Appendix B. Each batch of the clean resin must be evaluated for residual methylene chloride, and Total Chromatographable Organics and GRAVimetric residue (TCO/GRAV); the procedures and maximum allowable limits for each of these appears in Appendix B. Once cleaned, the resin should be stored in an airtight wide-mouth amber glass container with a Teflon®-lined cap or placed in one of the glass sorbent modules tightly sealed with Teflon film and elastic bands. The resin should be used within two weeks of preparation.

2.2.3 Silica Gel. Indicating type, 6 to 16 mesh. Dry at 175°C (350°F) for 2 hours before using.

2.2.4 Impinger Solutions. Distilled water shall be used, unless sampling is intended to quantify a particular inorganic gaseous species. Table 2 presents recommended impinger solutions for collecting specific inorganic species from exhaust gas streams.

2.3 Materials and Supplies Needed for Sample Recovery.

2.3.1 Methanol/Methylene Chloride. Distilled-in-glass or pesticide grade methanol and methylene chloride are required as a minimum.

2.3.2 Water. Distilled-deionized water shall be used to aid in quantitatively transferring any impinger solutions that will be analyzed.

TABLE 2. MM5 TRAIN RECOMMENDED IMPINGER SOLUTIONS

Species Removed from Gas Stream	Impinger Solution	Mechanism of Removal
Hydrochloric Acid	0.1 N or weaker[a] Hydroxide or Sodium Acetate or Sodium Carbonate[b]	Neutralization/dissolution
Heavy Metals (volatile and semi-volatile)	0.1 N Nitric Acid	Oxidative dissolution
Sulfur Dioxide	3-30% Hydrogen Peroxide	Oxidative dissolution
Sulfur Trioxide	80% Isopropanol[c]	Condensation/dissolution

[a] The use of caustic any stronger will result in the absorption of sufficient CO_2 from the stack gas to precipitate carbonate salts that may plug the center stem of one or more of the impingers.

[b] Sodium acetate and carbonate may be used as more concentrated solutions, provided that their solubility limits are not exceeded. Sodium acetate is a potential interference, however, in analyzing for chloride by ion chromatography.

[c] To measure the moisture collected in any impinger containing this solution, the solution must be weighed, not measured, as the volumes of water and isopropanol are not additive.

2.3.3 Probe Liner, Nozzle and Organic Module Brushes. Nylon bristle brushes with stainless steel wire handles are required. The probe brush shall have extensions of stainless steel, Teflon® or inert material equal to the length of the probe. The brushes shall be properly sized and shaped to brush out the probe liner, the nozzle and the organic module conditioning section.

2.3.4 Wash Bottles. Three Teflon® or glass wash bottles are recommended; polyethylene wash bottles should not be used as organic contaminants may be extracted by exposure to organic solvents used for sample recovery.

2.3.5 Glass Sample Storage Containers. Chemically resistant, borosilicate amber and clear glass bottles, 500 mL and 1,000 mL. Screw cap liners shall either be Teflon® or otherwise constructed to be leak free and resistant to chemical attack by organic recovery solvents.

2.3.6 Petri Dishes. Glass, sealed around the circumference with 2.54 cm (1 in.) Teflon® tape, for storage and transport of filter samples.

2.3.7 Graduated Cylinder and/or Triple-Beam Balance. To measure condensed water to the nearest 1 mL or 1 gram. Graduated cylinders shall have subdivisions no greater than 2 mL. Laboratory triple-beam balances capable of weighing to ±0.5 gram are required.

2.3.8 Nalgene Storage Containers. Screw cap polypropylene or polyethylene containers to store silica gel, and high-density linear polyethylene to store impinger solutions.

2.3.9 Funnels. To aid in the recovery of samples for organic analyses, glass funnels are required. Glass or plastic funnels may be used elsewhere, but the two types must be segregated.

3. Procedure.

3.1 Pretest Preparation.

The complexity of this method is such that, in order to obtain reliable results, field personnel should be trained in and familiar with the test procedures. All the components shall be maintained and calibrated according to the procedure described in Rom (4) and Vol. III of the EPA Quality Assurance Handbook (9).

Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record on each container the total weight of the silica gel plus container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in the impinger or sampling holder just prior to train assembly.

Check filters visually against light for irregularities and flaws or pinhole leaks. Label the shipping containers (glass petri dishes) and keep the filters in these containers at all times except during sampling and weighing.

Desiccate the filters at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight i.e., less than 0.5 mg change from previous weighing; record results to the nearest 0.1 mg. During each weighing the filter must not be exposed to the laboratory atmosphere and a relative humidity above 50 percent for a period greater than 2 minutes. Alternatively, unused filters may be oven dried at 105°C (220°F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Used filters must not be oven dried at any time, as heat will tend to desorb any organic material that has been collected.

3.2 Preliminary Determinations.

Select the sampling site and the minimum number of sampling points according to EPA Method 1 (2). Determine the stack pressure, temperature, and the range of velocity heads using EPA Method 2 (2). It is recommended that a leak-check of the pitot lines (EPA Method 2 (2), Section 3.1) be performed. Determine the stack gas moisture content using the EPA Approximation Method 4 (2) or its alternatives to establish estimates of isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in EPA Method 2 (2), Section 3.6. If the integrated EPA Method 3 (2) sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as the sample run.

Select a nozzle size based on the range of preliminary gas stream velocity measurements so that it is not necessary to change the nozzle in order to maintain isokinetic sampling rates. During the run, do not change the nozzle. Ensure that the proper differential pressure gauge is chosen for the range of velocities encountered; see Section 2.2 of EPA Method 2 (2).

Select a suitable probe liner and probe length so that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of the probe.

Typically three (3) dscm (105.9 dscf) of sample volume is required for the determination of the Destruction and Removal Efficiency (DRE) of POHC's from incineration systems (1). Additional sample volume shall be collected as necessitated by analytical detection limit constraints. To determine the minimum sample volume required, refer to the sample calculations in Section 5.

Determine the total length of sampling time needed to obtain the identified minimum volume by comparing the anticipated average sampling rate to the volume requirement. Allocate the same time to each traverse point defined by EPA Method 1 (2). It is recommended that the length of time sampled at each traverse point be an integer or an integer plus one half minute to avoid time keeping errors.

In some circumstances, e.g., batch cycles, it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas sample volumes.

3.3 Preparation of the Collection Train.

During preparation and assembly of the sampling train, keep all openings where contamination can occur covered with Teflon® film or aluminium foil until just prior to assembly or until sampling is initiated.

Fill the sorbent trap section of the organic module with approximately 40 grams of clean adsorbent resin. While filling, insure that the trap packs uniformly to eliminate the possibility of channeling. When freshly cleaned, many adsorbent resins carry a static charge, causing the resin to cling to the trap walls. This may be minimized by filling the trap in the presence of an ionizing source such as ^{210}Polonium which acts as an antistat to remove the static charge carried by the resin. Commercial antistatic devices are the Model-204* and Model-210*, available from the 3-M Company, Inc., St. Paul, MN.

Mark the probe with heat resistant tape or paint to denote the proper distance into the stack or duct for each sampling point.

Place 100 mL of distilled-deionized water or other appropriate solution, (Refer to Table 1) in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the silica gel plus impinger may be weighed together to the nearest 0.5 g and the weight recorded.

Using tweezers or clean disposal surgical gloves, place a labeled (identified) and preweighed filter in the filter holder. Be sure that the filter is properly centered and the gasket placed to prevent the sample gas stream from bypassing the filter. Check the filter for tears or lifting after assembly is complete.

When glass liners are used, install the selected nozzle using a Viton-A O-ring if stack temperatures are less than 260°C (500°F) and a woven glass fiber gasket when temperatures are higher. See Rom (4) for details. Other connecting systems using either 316 stainless steel or Teflon® ferrules may be used. When metal liners are used, install the nozzle as above or by a leak-free direct mechanical connection.

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*Registered trademarks of the 3-M Company, Inc., St. Paul, Mn.

Set up the train as in Figure 1. During assembly, do not use any silicone lubricant on ground glass joints that are located upstream of the organic module. A very light coating of silicone lubricant may be used on all ground glass joints that are located downstream of the organic module, but should be limited to the outer portion of the joints to prevent contamination of the sample. If necessary, a glass cyclone may be used between the probe and the filter holder when the total particulate catch is expected to contain large particles or when water droplets are present in the stack.

Connect all temperature sensors to an appropriate potentiometer/ display unit. Check all temperature sensors at ambient temperature.

Place crushed ice around the impingers and the organic module condensate knockout.

Turn on the sorbent module coolant recirculating pump and begin monitoring the sorbent module gas exit temperature. Insure proper sorbent module gas exit temperature before proceeding and again before any sampling is initiated. It is extremely important that the XAD-2® resin temperature never exceeds 50°C (122°F), as thermal decomposition will occur. During testing, the XAD-2® temperature must not exceed 21°C (70°F) for efficient capture of the semivolatile species of interest.

Turn on and set the filter and probe heating systems at the desired operating temperatures. Allow time for the temperatures to stabilize.

3.4 Leak-Check Procedures.

3.4.1 Pretest Leak-Check. Since the number of additional intercomponent connections in the MM5 Train (over the M5 Train) increases the possibility of leakage, a pretest leak-check is required. If a Viton-A O-ring or other leak-free connection is used in attaching the probe nozzle to the probe liner, the train should be leak tested by plugging the nozzle and evacuating to 280 mm Hg (15 in. Hg) vacuum.

Note: A lower vacuum may be used, provided that it is not exceeded during the test. If a woven glass fiber gasket is used to attach the nozzle, do not connect the probe to the train during the leak-check. Instead, leak test by first plugging the inlet to the filter holder (cyclone, if applicable), evacuate to 280 mm. Hg (15 in. Hg) vacuum. Then the probe should be connected to the train and the train leak-checked at 25 mm. Hg (1 in. Hg) vacuum. Alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 280 mm. Hg (15 in. Hg) vacuum. A leakage rate in excess of 4 percent of the average sampling rate or 0.00057 m^3/min (0.02 cfm), whichever is less, is unacceptable and must be corrected.

These specific leak-testing instructions described in Rom (4) are strongly recommended. Start the pump with fine adjust valve fully open and coarse adjust valve completely closed. Partially open the coarse adjust valve and slowly close the fine adjust valve until the desired vacuum is reached. Do not reverse direction of the fine adjust valve; this will cause water to back up into the organic module or between the impingers. If the desired vacuum is exceeded, either leak-check at this higher vacuum or terminate the leak-check as instructed below and begin again.

When the leak-check is completed, slowly remove the plug from the inlet to the probe, filter holder or cyclone (if applicable). When the vacuum drops to 127 mm (5 in.) Hg or less, immediately close the coarse adjust valve. Switch off the pumping system and reopen the fine adjust valve. Do not reopen the fine adjust valve until the coarse adjust valve has been closed. This prevents the water in the impingers from being forced backward into each other or the organic module and the silica gel from being entrained backward into the third impinger.

3.4.2 Leak-Checks During Sampling Run. If during the sampling run, a component (e.g., filter assembly, impinger or sorbent trap) change becomes necessary, a leak-check shall be conducted immediately after the interruption of sampling and before the change is made. The leak-check shall be done according to the procedure outlined in Section 3.4.1 except that it shall be done at a vacuum equal to or greater than the maximum value recorded at that point in the test. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate, the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall void the run unless it is impossible to repeat, in which case he/she shall record the leakage rate and plan to correct the sample volume as shown in Section 5.2 of this method. It should be noted that correction of the sample volume in this manner reduces the integrity of the pollutant concentration data generated and must be avoided.

Immediately after a component change, and before sampling is re-initiated, a leak-check similar to a pretest leak-check must also be conducted.

3.4.3 Post-test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. Use the procedure outlined above insuring that the leak-check is conducted at a vacuum equal to or greater than the maximum value recorded during the sampling run. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable. If, however, a higher leakage rate is obtained, the tester shall attempt to repeat the run as previously discussed. If the run cannot be repeated, the tester shall record the leakage rate, correct the volume as shown in Section 5.2 of this method and shall consider the data obtained of questionable reliability.

3.5.1 Sample Collection. Detailed instructions for collection of representative samples are presented in the paragraphs below. Field personnel should also refer to Vol. III of the EPA Quality Assurance Handbook (9) for additional sample collecting guidelines.

During the sampling run, maintain an isokinetic sampling rate to within 10 percent of true isokinetic. Maintain a temperature around the filter of 120 ± 14°C (248 ± 25°F) and a gas temperature entering the sorbent trap at a maximum of 21°C (70°F).

For each run, record the data required on a data sheet such as the particulate field data blank shown in Appendix A. Take care to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak-check, and when sampling is halted. Take readings at least once at each sample point during each time increment. Level and zero the manometer initially and periodically throughout the sampling run.

Clean the stack access ports prior to the test run to eliminate the possibility of sampling deposited material. To begin sampling, remove the nozzle covering, verify that the filter and probe heating systems are at the specified temperature, and that the pitot tube and probe are properly positioned. Place the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Nomographs are available which aid in the rapid adjustment of the isokinetic sampling rate without excessive computations. These nomographs are designed for use when the Type S pitot tube coefficient is 0.84 ± 0.02, and the stack gas equivalent density (dry molecular weight) is equal to 29 ± 4. Rom (4) details the procedure for using the nomographs. If the stack gas molecular weight and the pitot tube coefficient are outside the stated ranges, do not use the nomographs unless appropriate steps are taken to compensate for the deviations (7).

When the stack is under significant negative pressure (equivalent to the height of impinger stem) take care to close the coarse adjust valve before inserting the probe into the stack to prevent water from backing into the organic module. It may be necessary to turn the pump on with the coarse adjust valve closed.

When the probe is in position, block off the openings around the probe and stack access port to prevent unrepresentative dilution of the gas stream.

Traverse the stack cross-section, as required by EPA Method 1 (2). Take care not to bump the probe nozzle into the stack walls when sampling near the walls or when removing and inserting the probe through the access port.

During the test run, make periodic adjustments to keep the temperature of the filter holder and the organic module at the proper level; add more ice and, if necessary, salt to maintain a temperature of less than 20°C (68°F) at the condenser/silica gel outlet.

If the pressure drop across the filter or sorbent trap becomes too high, making isokinetic sampling rates difficult to maintain, the filter/sorbent trap may be replaced in the midst of a sample run. It is recommended that another complete filter holder/sorbent trap assembly be used rather than attempting to change the filter and resin themselves. Before a new filter holder/sorbent trap assembly is installed, conduct a leak-check. The total particulate weight shall include the summation of all filter/sorbent collections.

A single train shall be used for the entire sample run, except in cases where simultaneous sampling is required in two or more separate ducts or in cases where equipment failure necessitates a change of trains.

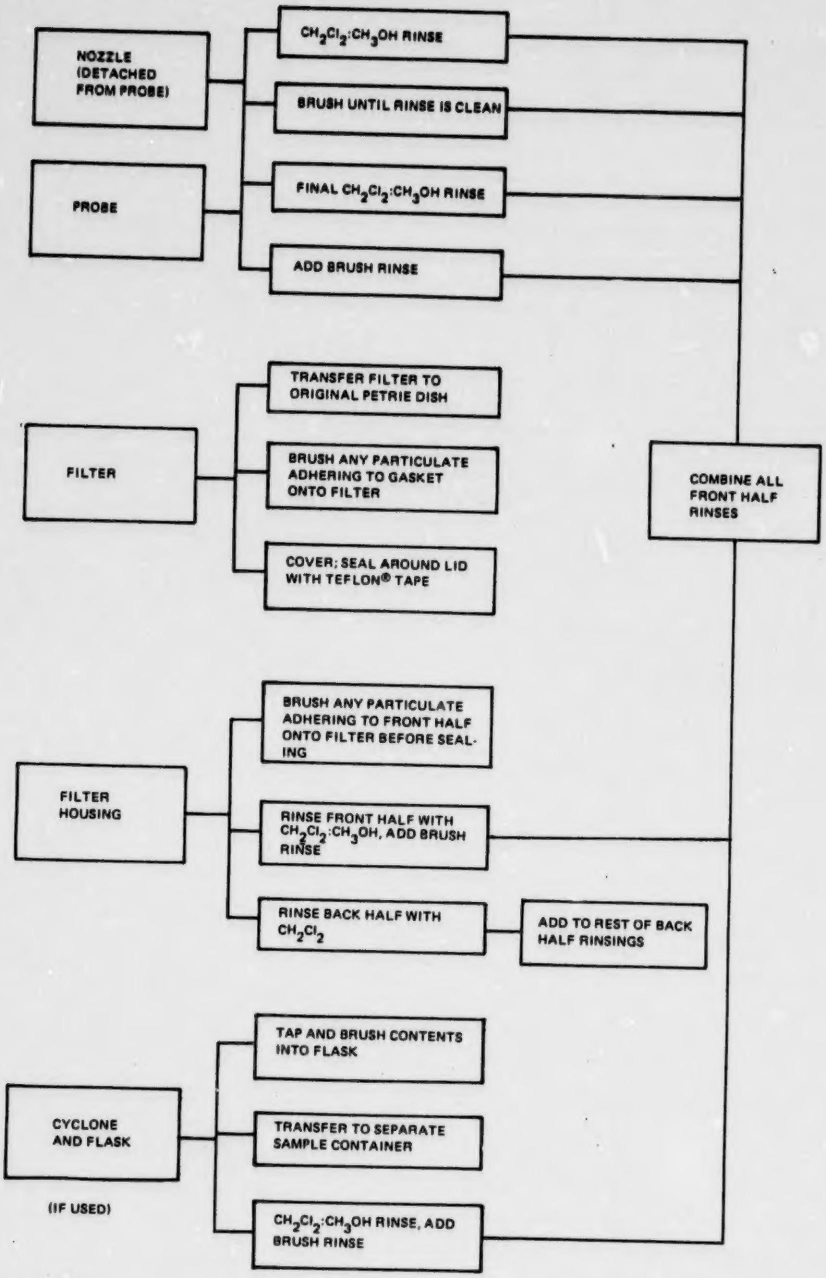
Note: When two or more trains are used, separate analysis of the front-half (if applicable) organic module and impinger (if applicable) catches from each train shall be performed, unless identical nozzle sizes were used on all trains. Then the front-half catches from the individual trains may be combined (as may the impinger catches) and one analysis of front-half catch and one analysis of impinger catch may be performed.

At the end of the sample run turn off the coarse adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check. Leak-check the pitot lines as described in EPA Method 2 (2), Section 3.1. The lines must pass this leak-check in order to validate the velocity head data.

Calculation of Percent Isokinecity. Calculate percent isokinetic (see Calculations, Section 5) to determine whether the results are acceptable or whether another test run should be made.

3.6 Sample Recovery.

3.6.1 Disassembly of the MM5 Train. Proper sample recovery begins as soon as the sampling period has ended. Extreme care must be taken to remove the probe from the stack without bumping or scraping it against the stack wall or sampling port flanges.


NOZZLE (DETACHED FROM PROBE)
PROBE
CH_2Cl_2:CH_3OH RINSE
BRUSH UNTIL RINSE IS CLEAN
FINAL CH_2Cl_2:CH_3OH RINSE
ADD BRUSH RINSE
FILTER
TRANSFER FILTER TO ORIGINAL PETRIE DISH
BRUSH ANY PARTICULATE ADHERING TO GASKET ONTO FILTER
COVER; SEAL AROUND LID WITH TEFLON® TAPE
COMBINE ALL FRONT HALF RINSES
FILTER HOUSING
BRUSH ANY PARTICULATE ADHERING TO FRONT HALF ONTO FILTER BEFORE SEALING
RINSE FRONT HALF WITH CH_2Cl_2:CH_3OH, ADD BRUSH RINSE
RINSE BACK HALF WITH CH_2Cl_2
ADD TO REST OF BACK HALF RINSINGS
CYCLONE AND FLASK
(IF USED)
TAP AND BRUSH CONTENTS INTO FLASK
TRANSFER TO SEPARATE SAMPLE CONTAINER
CH_2Cl_2:CH_3OH RINSE, ADD BRUSH RINSE

NOTES: ALL CH_2Cl_2:CH_3OH MIXTURES ARE 50:50 V/V.
ALL CONTAINERS FOR SAMPLES FOR ORGANIC ANALYSIS MUST BE GLASS.
USE TEFLON® OR GLASS WASH BOTTLES; TEFLON® IS PREFERRED.

Figure 5: MM5 Train sample handling

1. When the probe can be safely handled, conduct the post-test leak check. Do not cap the probe tip tightly for any longer than necessary to conduct this leak-check, as capping the probe tip while the sampling train is cooling tends to create a vacuum in the filter holder that will draw water from the impingers back into the sorbent module.

When the probe has completely cooled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent contamination of the sample.

Before moving the sampling train to the cleanup site, remove the probe from the sample train, and cap the open outlet, taking care not to lose any condensate that might be present. Cap the filter inlet. Remove the umbilical cord from the last impinger. If a flexible line is used between the organic module and the filter holder, disconnect the line at the filter holder and let any condensed water or liquid drain into the organic module.

2. Cap the filter holder outlet and the inlet to the organic module. Separate the sorbent trap section of the organic module from the condensate knockout trap and the gas conditioning section. Cap all organic module openings. Disconnect the organic module knockout trap from the impinger train inlet and cap both of these openings. Ground glass stoppers, Teflon®caps or caps of other inert materials may be used to seal all openings.

3. Transfer the probe, the filter, the organic module components and the impinger assembly to the clean-up area. This area should be clean and protected from the elements to minimize sample contamination or loss.

4. Save a portion of all washing solutions (methanol/methylene chloride mixture, methylene chloride only, distilled-deionized water) used for cleanup as a blank. Transfer 500 mL of each solution directly from the wash bottle used and place them in separate labeled glass sample containers.

5. Inspect the train prior to and during disassembly and note any abnormal conditions.

3.6.2 Sample Handling and Transfer. Step-by-step sample handling and transfer procedures are outlined below. Flow diagramatic representations of these recovery procedures are presented in Figures 5, 6, and 7. The quality assurance/quality control measures that must be incorporated into the sample recovery procedure are provided in Vol. III of the EPA Quality Assurance Handbook (9). An example coding format for MM5 samples follows in Table 3.

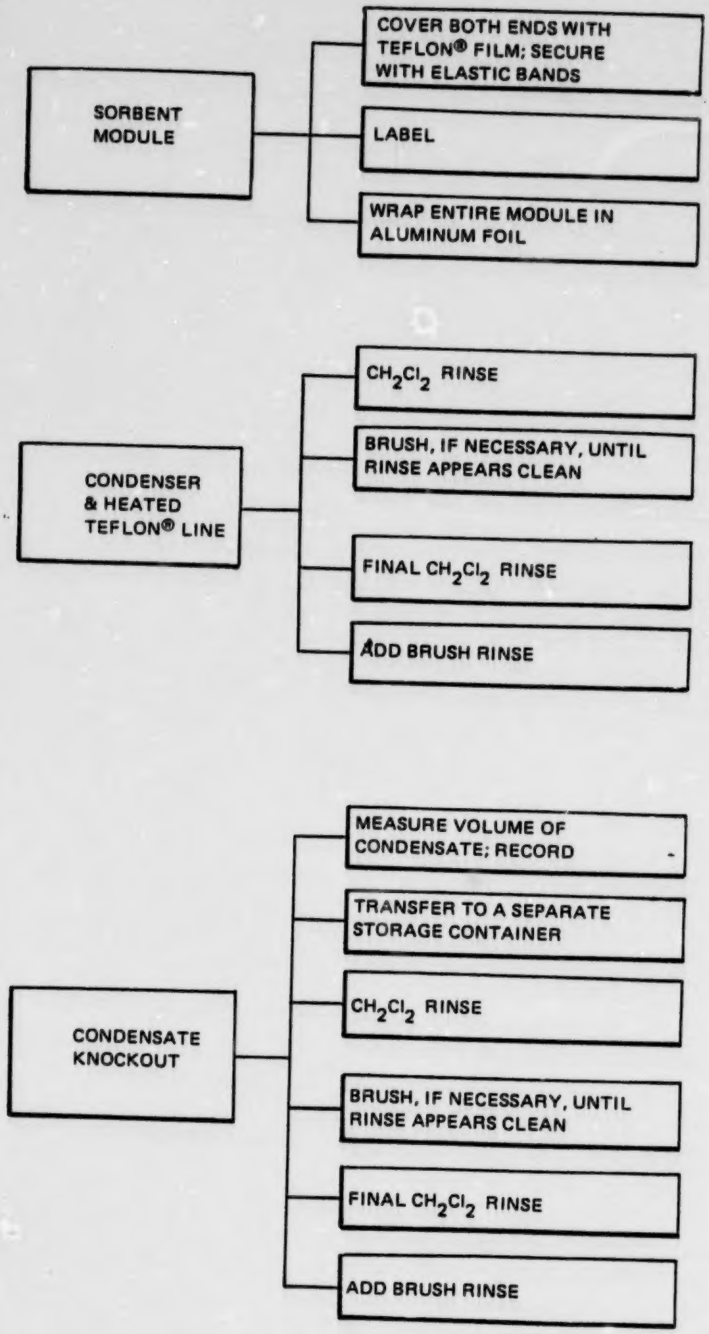
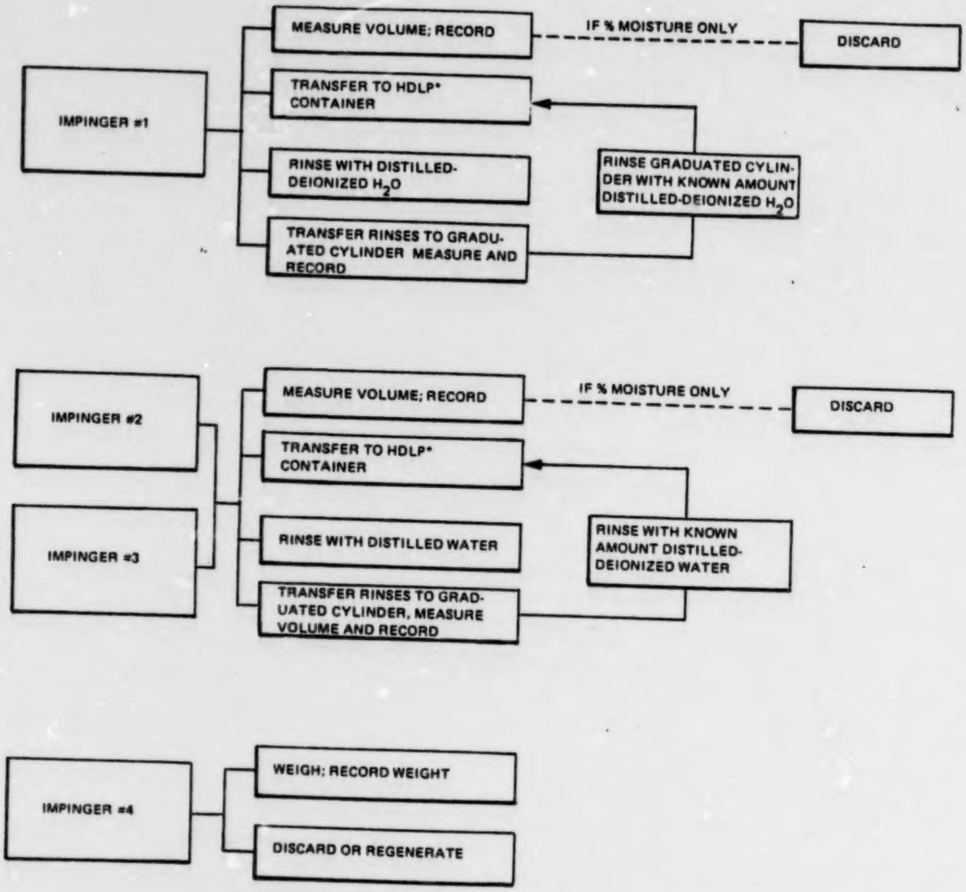

SORBENT MODULE
COVER BOTH ENDS WITH TEFLON® FILM; SECURE WITH ELASTIC BANDS
LABEL
WRAP ENTIRE MODULE IN ALUMINUM FOIL
CONDENSER & HEATED TEFLON® LINE
CH_2Cl_2 RINSE
BRUSH, IF NECESSARY, UNTIL RINSE APPEARS CLEAN
FINAL CH_2Cl_2 RINSE
ADD BRUSH RINSE
CONDENSATE KNOCKOUT
MEASURE VOLUME OF CONDENSATE; RECORD
TRANSFER TO A SEPARATE STORAGE CONTAINER
CH_2Cl_2 RINSE
BRUSH, IF NECESSARY, UNTIL RINSE APPEARS CLEAN
FINAL CH_2Cl_2 RINSE
ADD BRUSH RINSE

Figure 6: MM5 Train sample handling and transfer: organic module section.


IMPINGER #1
MEASURE VOLUME; RECORD
IF % MOISTURE ONLY
DISCARD
TRANSFER TO HDLP* CONTAINER
RINSE WITH DISTILLED-DEIONIZED H_2O
RINSE GRADUATED CYLINDER WITH KNOWN AMOUNT DISTILLED-DEIONIZED H_2O
TRANSFER RINSES TO GRADUATED CYLINDER MEASURE AND RECORD
IMPINGER #2
IMPINGER #3
MEASURE VOLUME; RECORD
IF % MOISTURE ONLY
DISCARD
TRANSFER TO HDLP* CONTAINER
RINSE WITH DISTILLED WATER
RINSE WITH KNOWN AMOUNT DISTILLED-DEIONIZED WATER
TRANSFER RINSES TO GRADUATED CYLINDER, MEASURE VOLUME AND RECORD
IMPINGER #4
WEIGH; RECORD WEIGHT
DISCARD OR REGENERATE

* HDLP = HIGH-DENSITY LINEAR POLYETHYLENE.

Figure 7: MM5 Train sample handling and transfer: impinger train.

TABLE 3. EXAMPLE CODING FORMAT FOR MM5 TRAIN SAMPLES

Sample Code	Container	Size	Sample Description
CC	Amber Glass	100 mL, wide-mouth	Cyclone catch (if applicable)
PF-a,b,c..	Glass petri dish(es)	150 mm diameter	Particulate filter(s)
FHR	Clear glass*	1L	Front-half rinse (50:50 Methanol/methylene chloride)
SMB	Clear glass*	500 mL	Solvent mixture blank (50:50 Methanol/methylene chloride)
BHR	Clear glass*	1 L	Back half rinse (methylene chloride)
SB	Clear glass*	500 mL	Solvent blank (methylene chloride)
XAD-a,b,c..	Amber glass	100 mL, wide-mouth or capped sorbent traps	XAD-2®resin sample(s) (and rinse if applicable)
CD	Amber glass	1L	Condensate knockout catch
I1	HDLP**	1L	First impinger catch
I1B	HDLP**	1L	First impinger blank (appropriate collecting solution)
I2,3	HDLP**	1L	Second and third impinger catches combined
I2,3,B	HDLP**	1L	Second and third impinger blank (appropriate collecting solution)

*must be clear to allow tester to verify when components have been "rinsed clean"; cover with aluminum foil to protect sample from light.

**HDLP = High-density linear polyethylene

3.6.3 Probe, Nozzle, Cyclone (if used), Filter Recovery.

1. Carefully remove the filter from the filter holder and place it in its identified petri dish. Use two pairs of tweezers to handle the filter. If it is necessary to fold the filter, insure that the particulate cake is inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers which adhere to the filter holder gasket, using a dry nylon bristle brush and/or a sharp-edged blade. Label the container and seal with 2.54 cm (1 in.) Teflon tape around the circumference of the lid.

2. Taking care to see that dust on the outside of the probe or other exterior surfaces does not contaminate the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe liner, and front half of the filter holder by washing these components with methanol/methylene chloride (1:1 v/v) into a glass container. Distilled water may also be used. Retain a water and solvent blank and analyze in the same manner as the samples. Perform rinses as follows:

Carefully remove the probe nozzle and clean the inside surface by rinsing with the solvent mixture (1:1 v/v methanol/methylene chloride) from a wash bottle and brushing with a nylon bristle brush. Brush until the rinse shows no visible particulate material. Then make a final rinse of the inside surface with the solvent mix.

Have two people rinse the probe liner with the solvent mix by tilting and rotating the probe while squirting solvent into its upper end so that all inside surfaces will be wetted with solvent. Let the solvent drain from the lower end into the sample container. A funnel (glass) may be used to aid in transferring liquid washes to the container. Follow the solvent rinse with a brushing. Both persons should support the probe in an inclined position, while one sprays solvent into the upper end of the liner and pushes the probe brush with a twisting action through the probe; the second person must place a sample container underneath the lower end of the probe, and catch any solvent and particulate matter which is brushed from the probe. Run the brush through the probe three or more times until no visible particulate material is carried out with the solvent or until none remains in the probe liner on visual inspection. With stainless steel or other metal probes, it is necessary to run the brush through in this manner at least six times since these probes have small crevices in which particulate matter can be entrapped. Rinse the brush with solvent, and quantitatively collect these washings in the sample container. After the brushing, make a final solvent rinse of the probe. Between sampling runs, keep brushes clean and protected from contamination.

3. Clean the inside of the front half of the filter holder and cyclone/cyclone flask, if used, by rubbing the surfaces with a nylon bristle brush and rinsing with methanol/methylene chloride (50:50) mixture. Rinse each surface at least three times to remove visible

particulate. Make a final rinse of the brush and filter holder. Carefully rinse out the glass cyclone and cyclone flask (if used). Brush and rinse any particulate material adhering to the inner surfaces of these components into the front-half rinse sample. After all solvent washings and particulate matter have been collected, tighten the sample container lid so that solvent will not leak out during shipment to the laboratory. Mark the height of the fluid level to determine if leakage occurs during transport. Label the container clearly to identify its contents.

4. Rinse the back half of the filter holder in the same manner into a separate container with methylene chloride only. Combine this rinse with the condenser, sorbent module and condensate knockout rinses described in the next subsection.

3.6.4 Condenser, Sorbent Module and Condensate Knockout Recovery

1. The sorbent trap section of the organic module may be used as a sample transport container, or the spent resin may be transferred to a separate glass bottle for shipment. If the sorbent trap itself is used as the transport container, both ends should be sealed with tightly fitting caps or plugs. Ground glass stoppers or Teflon® caps may be used. The sorbent trap should then be labeled, covered with aluminum foil and packaged for transport to the laboratory.

If a separate bottle is used, the spent resin should be quantitatively transferred from the trap into the clean bottle. Resin that adheres to the walls of the trap should be recovered using a stainless steel or Teflon® spatula and added to this bottle. If rinsing of the trap is necessary for the quantitative transfer, methylene chloride only should be used; the rinsings may be added to the resin sample container.

2. Measure the volume of condensate collected in the condensate knockout section of the organic module to within ±1 mL using a graduated cylinder or by weighing to within ±0.5 g using a triple-beam balance. Record the volume or weight of liquid present, and note any discoloration or film in the liquid catch. Transfer this liquid to a labeled glass container. Inspect the gas conditioning section of the organic module. If condensate is observed, transfer it to a graduated or weighed bottle and measure the volume or weight as described above. Add this material to the condensate knockout trap catch.

3. All sampling train components located between the high efficiency glass or quartz fiber filter and the first wet impinger (including the heated Teflon® line connecting the filter outlet to the condenser) should be thoroughly rinsed with methylene chloride, and the rinsings combined. The rinsings shall be separated from the condensate. If the spent resin is transferred from the sorbent trap to a separate sample container for transport, the sorbent trap shall be thoroughly rinsed until all sample wetted surfaces appear clean. Visible films should be removed by brushing. Whenever train components are brushed, the brush should be subsequently rinsed with solvent mixture and the rinsings added to the appropriate sample.

3.6.5 Silica Gel and Impingers Recovery

1. Note the color of the indicating silica gel to determine if it has been completely spent and make a notation of its condition. Transfer the silica gel from the fourth impinger to its original container and seal. A funnel may facilitate pouring the silica gel without losses. A rubber policeman may be used to aid in removing the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use water or other liquids in the transfer. If a balance is available in the field, weigh the container and its contents to 0.5 g or better.

2. Recover the impingers as follows: Make a notation of any color or film in the liquid catch. Measure the liquid which is in the first three impingers to within ±1 mL by using a graduated cylinder or by weighing it to within ± 0.5 g using a triple-beam balance. Record the volume or weight of liquid present. This information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Table 2). Nalgene®*high-density linear polyethylene (HDLP) containers may be used for storage of the impinger catches.

3.6.6 Sample Preparation for Shipment Prior to shipment recheck all sample containers to insure that the caps are well secured. Seal the lids of all Nalgene® HDLP containers around the circumference with vinyl tape and those of the glass containers with Teflon®tape. Ship all liquid samples upright on ice and all particulate filters with the particulate catch facing upward. The particulate filters may be shipped unrefrigerated.

4. Calibration.

4.1 Probe Nozzle.

Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.) Measure the diameter of the nozzle face opening in 3 separate places (i.e. across 3 different diameters) and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm. (0.004 in.).

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*Nalgene®is a registered trademark of the Nalge Company, Division of Sybron Corporation, Rochester, NY 14602.

When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

4.2 Pitot Tube/Probe Assembly.

The Type S pitot tube probe assembly shall be calibrated according to the procedure outlined in Section 4 of EPA Method 2 (2), or assigned a nominal coefficient of 0.84 if it is not visibly nicked, dented or corroded, and meets design and intercomponent spacing specifications.

4.3 Metering System.

Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in Rom (4). It is recommended that a leak-check be conducted before calibrating the metering system. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect leakages within the pump. In these cases the following leak-check procedure is suggested: Make a 10-minute calibration run at 0.00057 m^3/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volumes; divide the difference by 10 to get the leak rate. The leak rate should not exceed 0.00057 m^3/min (0.02 cfm). Alternatively, the following procedure is suggested (see Figure 8): Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) of water by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single intermediate orifice setting (based on the previous field test). The vacuum shall be set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and the inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in Rom (4).

Note: If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

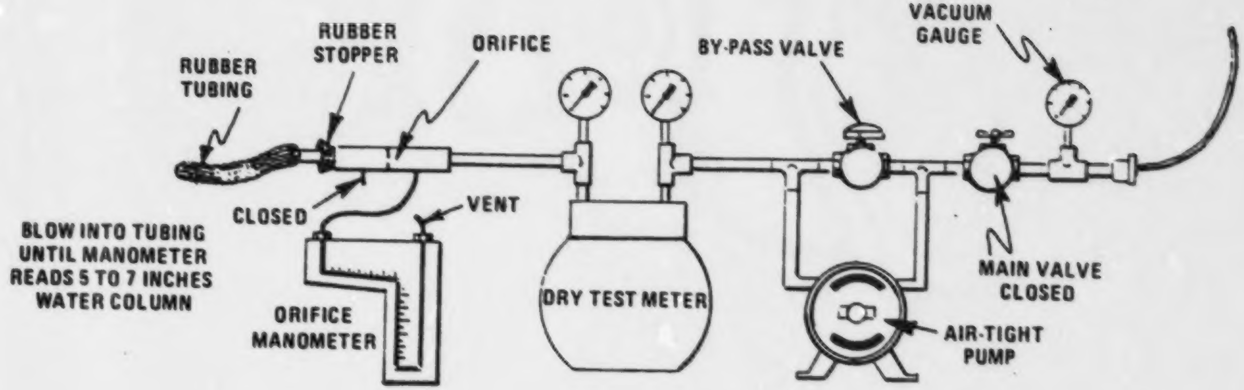
RUBBER TUBING
RUBBER STOPPER
ORIFICE
BY-PASS VALVE
VACUUM GAUGE
BLOW INTO TUBING UNTIL MANOMETER READS 5 TO 7 INCHES WATER COLUMN
CLOSED
VENT
ORIFICE MANOMETER
DRY TEST METER
MAIN VALVE CLOSED
AIR-TIGHT PUMP

Figure 8: Meter box leak-check apparatus

4.4 Probe Heater.

The probe heating system shall be calibrated before its initial use in the field according to the procedure outlined in Rom (4). Probes constructed according to Martin (3) need not be calibrated if the calibration curves in Rom (4) are used.

4.5 Temperature Gauges.

Each thermocouple must be permanently and uniquely marked on the casing; all mercury-in-glass reference thermometers must conform to ASTM E-1 #63C or 63F specifications. Thermocouples should be calibrated in the laboratory without the use of extension leads. If extension leads are used in the field, the thermocouple reading at ambient air temperatures, with and without the extension lead, must be noted and recorded. Correction is necessary if the use of an extension lead produces a change greater than 1.5%.

4.5.1 Impinger, Organic Module and Dry Gas Meter Thermocouples. For the thermocouples used to measure the temperature of the gas leaving the impinger train and the XAD-2®resin bed, a three-point calibration at ice water, room air, and boiling water temperatures is necessary. Accept the thermocouples only if the readings at all three temperatures agree to ± 2°C (3.6°F) with those of the absolute value of the reference thermometer.

4.5.2 Probe and Stack Thermocouple. For the thermocouples used to indicate the probe and stack temperatures, a three-point calibration at ice water, boiling water and hot oil bath temperatures must be performed; it is recommended that room air temperature be added as a fourth calibration point. If the absolute values of the reference thermometer and the thermocouple agree to within 1.5% at each of the calibration points, a calibration curve (equation) may be constructed (calculated), and the data extrapolated to cover the entire temperature range suggested by the manufacturer.

4.6 Aneroid Barometer.

Adjust the barometer initially and before each test series to agree to within ± 2.5 mm Hg (0.1 in. Hg) of the mercury barometer, or the corrected barometric pressure value reported by a nearby National Weather Service station.

4.7 Triple-Beam Balance.

Calibrate the triple beam balance before each test series using Class-S standard weights; the weights must be within ± 0.5% of the standards, or the balance adjusted to meet these limits.

5. Calculations.

Carry out the calculations, insuring that the final number of significant figures are preserved after the final calculation. Other forms of the equations may be used provided the results are equivalent.

5.1 Nomenclature

A_n = Cross sectional area of nozzle, $m^2(ft^2)$

B_{ws} = Water vapor in the gas stream, proportion by volume

C_d = Type S pitot tube coefficient (nominally 0.84 ± 0.02), dimensionless

C_{mm} = Methanol/methylene chloride blank correction, mg/g of solvent

C_p = Concentration of particulate material in the stack gas, g/dscm (gr/dscf)

I = Percent of isokinetic sampling

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate

L_i = Individual leakage rate observed during the leak check conducted prior to the "i"th component change (i=1, 2, 3.....n) m^3/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m^3/min (cfm)

M_{mm} = Mass of methanol/methylene chloride after evaporation, mg

M_d = Stack gas dry molecular weight, g/g-mole (lb/lb-mole)

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole)

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg)

P_s = Absolute stack gas pressure, mm. Hg (in. Hg)

P_{std} = Standard absolute pressure, 760 mm. Hg(21.85 in. Hg)

T_m = Absolute average dry gas meter temperature, °K(°R)

T_s = Absolute average stack gas temperature, °K(°R)

T_{std} = Standard absolute temperature, 293°K (528°R)

V_{mm} = Volume of methanol/methylene chloride used for front-half wash, mL

V_{lc} = Total volume of liquid collected in the organic module condensate knockout trap, the impingers and silica gel, mL

V_m = Volume of gas sample as measured by dry gas meter, $m^3(ft^3)$

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf)

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf)

v_s = Stack gas velocity, calculated by EPA Method 2 (2), Equation 2-9, using particulate field data, m/sec (ft/sec)

W_{mm} = Weight of residue in methanol/methylene chloride wash, mg

W_{cc} = Weight of particulate cyclone catch, mg

W_p = Total weight of particulate material collected during run, mg

W_{pf-a}, W_{pf-b}, $W_{pf-c...}$ = Particulate weight of all filters used during the run, mg

W_{pr} = Weight of sample front-half rinse before blank correction, mg

Y = Dry gas meter calibration factor, dimensionless

ΔH = Average pressure differential across the orifice meter, mm H_2O (in. H_2O)

ρ_w = Density of water, 0.9982 g/mL (0.002201 lb/mL)

ρ_{mm} = Density of methanol/methylene chloride (50:50 v/v) mixture, g/mL (see labels on bottles)

θ = Total sampling time, min

θ_1 = Sampling time interval between two successive component changes beginning with the interval between the first and second changes, min

θ_p = Sampling time interval from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury

60 = Sec/min

5.2 Dry Gas Volume at Standard Conditions.

Correct the sample volume measured by the dry gas meter to standard conditions (20°C, 760 mm Hg or 68°F, 29.92 in. Hg) by using the equation:

$$V_{m(std)} = V_m Y \left[\frac{T_{std}}{T_m}\right] \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{std}}\right]$$

$$= K_1 V_m Y \left[\frac{P_{bar} + (\Delta H/13.6)}{T_m}\right]$$

where:

K_1 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

Note: This equation can be used as written unless the leakage rate observed during any of the leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_a. If L_p or L_i exceeds L_a, the above equation must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m with the expression:

$$\left[V_m - \theta(L_p - L_a)\right]$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m by the expression:

$$\left[V_m - \theta_1(L_1 - L_a)\right]$$

$$- \sum_{i=2}^{n} \left[\theta_i(L_1 - L_a) - \theta_p(L_p - L_a)\right]$$

and substitute only those leakage rates (L_i or L_p) which exceed L_a.

5.3 Moisture Content.

5.3.1 Volume of Water Vapor.

$$V_{w(std)} = V_{1c}\left[\frac{P_w}{M_w}\right]\left[\frac{RT_{std}}{P_{std}}\right] = K_2 V_{1c}$$

where:

K_2 = 0.001333 m^3/mL for metric units
= 0.04707 ft^3/mL for English units

5.3.2 Percent Moisture.

$$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

Note: In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made: one from the impinger analysis, and a second from the assumption of saturated conditions. The lower of the two values shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in Section 1.2 of EPA Method 4 (2). For the purposes of this method, the average stack gas temperature measured during the sampling run may be used to make this determination.

5.4 Particulate Concentration.

5.4.1 Unit Blank Weight Correction. Calculate for all front-half samples as follows:

$$C_{mm} = \frac{M_{mm}}{V_{mm}\rho_{mm}}$$

5.4.2 Blank Weight Correction for Each Sample. Calculate for the individual front-half samples using the equation:

$$W_{mm} = C_{mm} V_{mm} \rho_{mm}$$

5.4.3 Blank-corrected Total Particulate Weight. Calculate according to:

$$W_p = (W_{pf-a} + W_{pf-b} + W_{pf-c} + \ldots\ldots) + W_{cc} + (W_{pr} - W_{mm})$$

5.4.4 Particulate Concentration. Calculate using the equation:

$$C_p = (0.001\ \mathrm{g/mg})\ \frac{W_p}{V_{m(std)}}$$

5.4.5 Conversion Factors:

From	To	Multiply by
scf	m^3	0.02832
g/ft^3	gr/ft^3	15.43
g/ft^3	lb/ft^3	2.205 x
g/ft^3	g/m^3	35.31

5.5 Isokinetic Variation.

5.5.1 Calculation from Unreduced Data.

$$I = \frac{100\ T_s\ K_3 F_{1c} + (V_m/T_m)\ (P_{bar} + H/13.6)}{60\ v_s P_s A_n}$$

where:

K_3 = 0.003454 mm Hg-m^3/mL-°K for metric units
= 0.002669-in. Hg-ft^3/mL-°R for English units

5.5.2 Calculation from Intermediate Values.

$$I = \frac{T_s V_{m(std)} P_{std} 100}{T_{std} v_s\ A_n P_s 60(1-B_{ws})}$$

$$= K_4\ \frac{T_s V_{m(std)}}{P_s v_s A_n\ (1-B_{ws})}$$

where:

K_4 = 4.320 for metric units
= 0.09450 for English units

5.5.3 Acceptable Results. If 90% I 110%, the results are acceptable.

5.6. Minimum Sample Volume.

To determine the minimum sample volume that shall be collected, the following sequence of calculations shall be used:

5.6.1 Maximum POHC Mass Flow Rate. From prior analysis of the waste feed the concentration of Principal Organic Hazardous Compounds (POHCs) introduced into the combustion system can be calculated. The

(POHCs) introduced into the combustion system can be calculated. The degree of Destruction and Removal Efficiency (DRE) that is required is used to determine the maximum amount of POHC allowed to be present in the effluent. This may be expressed as:

$$\text{Max POHC}_i \text{Mass Flow Rate} = \frac{(\text{WF})(\text{POHC}_i \text{ conc})(100\text{-}\%\text{DRE})}{100}$$

where:

Max POHC Mass Flow Rate = Maximum mass flow rate, gm/hr (lb/hr) of POHC emitted from the combustion source when the required DRE is met

WF = Mass flow rate of waste feed per hour, gm/hr (lb/hr)

POHC_i = Concentration of Principal Organic Hazardous Compounds (POHC's) in the waste introduced into the combustion process, wt%

DRE = Percent Destruction and Removal Efficiency (DRE) required, %

5.6.2 Maximum POHC Discharge Concentration. The average discharge concentration of the POHC in the effluent gas is determined by comparing the Max POHC Mass Flow Rate to the volumetric flow rate being exhausted from the source. Volumetric flow rate data are available as a result of preliminary EPA Method 1-4 (2) determinations.

$$\frac{\text{Max POHC}_i \text{ Mass Flow Rate}}{V_{\text{eff(std)}}} = \text{Max POHC}_i \text{ Concentration}$$

where:

$V_{\text{eff(std)}}$ = Volumetric flow rate of effluent gas, dscm (dscf)

Max POHC_i Concentration = Anticipated maximum concentration of the POHC in the exhaust gas stream, gm/dscm. (lb/dscf)

Knowing the lower detection limit of the analytical technique allows the determination of the minimum volume of effluent gas that must be sampled to insure that a sufficient quantity of material is collected.

5.6.3 Minimum Gas Volume to be Collected. In calculating the minimum volume of gas sample required, it is recommended that a safety margin of at least ten (10) be included: (1,10)

$$\frac{\text{LDL}_{\text{POHC}} \times 10}{\text{Max POHC}_i \text{ Concentration}} = V_{\text{TBC}}$$

where: LDL_{POHC} = Lower detection limit of POHC, gm (lbs)
V_{TBC} = Minimum dry standard volume to be collected at dry gas meter, dscm (dscf)

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III. Source Assessment Sampling System (SASS) Collection Procedure for Particulate and Semivolatile Organic Emissions from Industrial Sources.

1. Principle and Applicability.

1.1 Principle.

Particulate and semi-volatile organic materials are withdrawn from a source at constant rate near isokinetic conditions and are collected in a multi-component sampling train.

Three heated cyclones and a heated high-efficiency glass or quartz fiber filter remove and collect the particulate material from the sample, and a packed bed of porous polymeric resin adsorbs the semivolatile organic species.

Chemical analyses of the sample are conducted to determine the concentration and identity of the semi-volatile organic species and gravimetric determinations are performed to approximate particulate emissions.

1.2 Applicability.

This method is applicable to the determination of the Destruction and Removal Efficiency (DRE) of the Principal Organic Hazardous Compounds (POHC's) from incineration systems (1). This method is not approved for compliance determination of particulate emission rates because isokinetic sampling conditions cannot be guaranteed.

2. Apparatus.

2.1 Sampling Train.

A schematic of the sampling train used in this method is given in Figure 9. This sampling train configuration is that of the Source Assessment Sampling System (SASS) as supplied by Anderson Samplers, Inc., Atlanta, GA. Basic operating and maintenance procedures are described in the "Operating and Service Manual: Source Assessment Sampling System" (2) supplied with the purchase of the sampling system. Users should refer to the above document and adopt, but not limit themselves to, those operating and maintenance procedures. The following subsections list the SASS components and specifications as supplied.

2.1.1 Probe Nozzles. The probe nozzles are constructed of Type 316 seamless stainless steel tubing and have sharp leading edges. The nozzles are a hybrid elbow/button-hook design, available in diameters ranging from 0.31 to 1.91 cm (1/8 to 3/4 in.), and are interchangeable. Each nozzle should be calibrated according to the procedure outlined in Section 4.

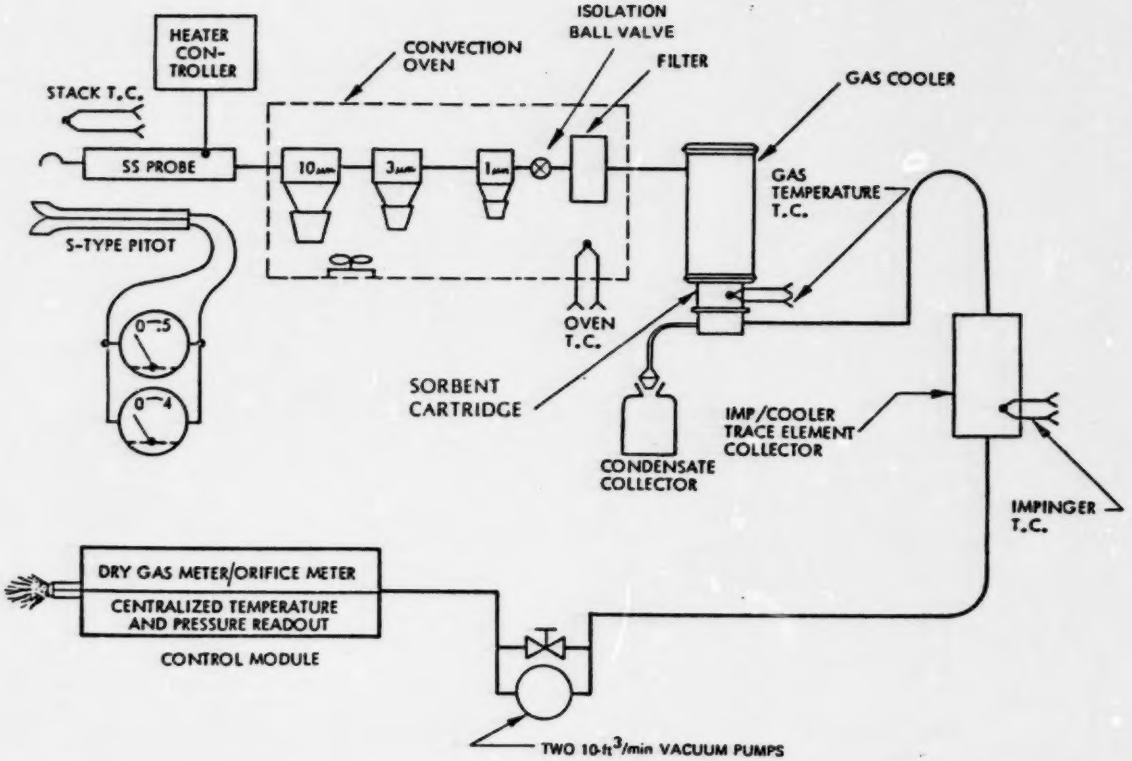
HEATER CON- TROLLER
STACK T.C.
SS PROBE
S-TYPE PITOT
0—.5
0—4
CONVECTION OVEN
10µm
3µm
1µm
ISOLATION BALL VALVE
FILTER
OVEN T.C.
GAS COOLER
GAS TEMPERATURE T.C.
SORBENT CARTRIDGE
CONDENSATE COLLECTOR
IMP/COOLER TRACE ELEMENT COLLECTOR
IMPINGER T.C.
DRY GAS METER/ORIFICE METER
CENTRALIZED TEMPERATURE AND PRESSURE READOUT
CONTROL MODULE
TWO 10-ft³/min VACUUM PUMPS

Figure 9: SASS schematic diagram
Source: IERL Procedures Manual: Level 1
Environmental Assessment Second Edition),
EPA-600/7-78-201

interchangeable. Each nozzle should be calibrated according to the procedure outlined in Section 4.

2.1.2 Probe Liner. The probe liner is also constructed of Type 316 stainless steel seamless tubing; attached to the liner is a proportional temperature controller capable of maintaining the liner surface temperature at 204 ± 20°C (400 ± 36°F) during sampling. The use of the proportional controller to modulate the liner surface temperature at the control box is preferred because the oven often cannot be reached for adjustment during sampling.

It should be noted that the measurement of the probe liner surface temperature is not an accurate measurement of the internal gas stream temperature, which is the temperature of interest. The temperature gradient that exists between the inner and outer walls of the liner is the reason for this source of error. Monitoring of the actual gas stream temperature is impractical with the SASS train as presently constructed. It is suggested that a one-time calibration be conducted in which the internal gas stream temperature is compared to the liner surface at various temperatures and at the SASS design flow rate of 0.113 scmm (4.0 scfm).

The probe/probe liner assembly can withstand temperatures up to 370°C (700°F) at which temperature it will soften. However, stack temperatures greater than 288°C (550°F) may result in gas temperatures at the 10 um cyclone inlet greater than the recommended 204°C (400°F); in these cases the use of a special water- or forced-air-cooled probe is recommended.

2.1.3 Pitot tube. The pitot tubes are the Type S, designed to meet the specifications of EPA Method 2 (3); these are attached to the front end of the probe sheath to allow constant monitoring of the stack gas velocity. The point of attachment to the sheath is such that the impact (high pressure) opening plane of the pitots is level with or above the sampling nozzle entry plane, as required by EPA Method 2 (3) to eliminate nozzle interference in velocity measurements. If calibration is not required, the pitot tubes are assigned a nominal coefficient of 0.84, as described in Section 5.

2.1.4 Differential Pressure Gauges. Three Magnehelic®* type gauges are used: one gauge (0 to 0.5 in. H_2O) for monitoring the pressure drop across the orifice meter (ΔH_1); the other two gauges (0 to 0.5 and 0 to 4.0 in. H_2O) are connected in parallel and indicate the pressure differential across the pitot tubes used for measuring stack gas velocity.

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*Magnehelic®is a registered trademark of Dwyer Instruments, Inc., Michigan City, IN.

2.1.5 Filter Holder and Filter Support. The filter holder and filter support screen are constructed of Type 316 stainless steel. The inner surfaces of the holder are Teflon®-coated to eliminate the need for a sealing gasket to which the filter might stick during recovery. The holder is attached immediately to the outlet of the 1 um cyclone or the cyclone by-pass.

2.1.6 Cyclone/Filter Heating System. The cyclone/filter heating system is an insulated double-walled oven, capable of maintaining the temperature in the area of the cyclones and filter holder around the recommended 204°C (400°F). A chromel-alumel thermocouple for temperature sensing allows feedback control of the temperature to within approximately 10%.

2.1.7 Cyclone Train. The cyclone train consists of 3 cyclone separators in series, having nominal particle size cutoff diameters of 10-, 3- and 1-um, respectively. The material of construction is Type 316 stainless steel with Teflon® or Viton-A O-ring gaskets sealing the hoods and collector cups. The compact design of the 10-um cyclone is achieved by incorporating flow-interrupting vanes in the collection cup (4).

2.1.8 Organic Module. The organic module consists of a thin-film heat exchanger/gas cooler, a sorbent cartridge, and a condensate collection trap. The temperature of the heat exchanger fluid is regulated by activating an immersion heater or routing the coolant through a heat exchanger in the impinger ice water bath. Water from the impinger bath is continually circulated through the inner reservoir of the gas cooler for additional cooling capacity. The sorbent cartridge encloses the polymeric adsorbent bed in a cylinder covered on both ends by 80 mesh, Type 316 stainless steel wire cloth. The cartridge holds approximately 130 grams of XAD-2.® Condensed moisture from the gas stream is collected in a stainless steel reservoir located directly beneath the packed sorbet bed. The drain valve of the reservoir is coupled with a Teflon® line to an appropriately-sized (1-5 liters) glass storage container, (these two items are not supplied by the SASS manufacturer) as the capacity of the reservoir will typically be exceeded during a run.

2.1.9 Impinger Train. The four impingers have a capacity of approximately 3 liters each and are constructed of borosilicate glass. The caps are Teflon® with stainless steel fittings and the impingers are interconnected by flexible Teflon® or stainless steel tubing. The first two impingers are equipped with splash guards to minimize fluid carry over. The last impinger is fitted with a thermocouple mounted in the cap for monitoring the impinger train exit gas temperature.

2.1.10 Metering System. Two leak-free vane-type vacuum pumps connected in parallel are used to maintain the 0.133 scmm (4.0 scfm) design flow in the sampling system. Vacuum gauges, and differential pressure gauges, thermocouples capable of measuring temperature to with 3°C (5.4°F), and a dry gas meter capable of measuring volume to within one percent are supplied as the basic components for maintaining near-isokinetic sampling rates.

2.1.11 Barometer. An aneroid or other barometer capable of measuring atmospheric pressure to within 2.5 mm. Hg (0.1 in. Hg) is required, unless the barometric reading is obtained from a nearby national weather station; the station value (i.e., the absolute barometric pressure) must be corrected for elevation differences between the weather station and the sampling point. The corrected value should reflect a decrease of 2.5 mm. Hg (0.1 in. Hg) per 30 m. (100 ft.) elevation increase and vice versa for elevation decrease. The field barometer must be calibrated against a mercury barometer as described in Section 4.

2.1.12 Crushed Ice. Commercially available. Quantities ranging from 50-150 lb. may be necessary depending upon ambient temperatures.

2.1.13 Gas Density Determination Apparatus. The nonreactive fixed gas samples for determining the average stack gas density during the SASS run are taken using an integrated gas sampling train. The gas sample is bled through a nonreactive probe and an air-cooled condenser (or equivalent) using a small diaphragm pump. The air-cooled condenser (or equivalent) removes excess moisture from the gas stream and cools the hot gas to ambient temperatures. The sampling flowrate is measured with a flow rate meter and controlled by adjustment of a needle valve. The sample is collected in a nonreactive leak-free bag and analyzed with an ORSAT apparatus or by gas chromatography with thermal conductivity detection (GC/TCD). The Level 1 Procedures Manual (5) includes detailed specifications of an integrated fixed gas sampling system.

2.1.14 Calibration/Field Preparation Record. For recording calibration and preparation procedures, (i.e. filter and silica gel tare weights, clean XAD-2®, quality assurance/quality control check results, dry gas meter and thermocouple calibrations, etc.) a permanently-bound laboratory notebook is required, in which duplicate copies are made of the data as it is being recorded. The duplicate copies should be detachable and stored separately in the test program archives.

2.2 Sample Collection Media.

2.2.1 Filters. Glass or quartz fiber filters 15.24 cm (6.0 in) diameter without organic binder, exhibiting 99.95 percent efficiency (< 0.05 percent penetration) on 0.3 um dioctyl phthalate smoke particles, conforming to the specifications outlined in ASTM Standard Method D2986-71 (6) are necessary. Test data from the supplier's quality control program are sufficient for this purpose. The filter material must also be unreactive to SO_2 and SO_3. Recommendations of suitable filter materials are provided in Citation 7, Section 6 of this report (7).

2.2.2. Adsorbent Resin. Porous polymeric resin XAD-2® is used. The resin must be cleaned prior to use, according to the procedure outlined in Appendix B. Each batch of the clean resin must be evaluated for residual methylene chloride and TCO/GRAV residues; the procedures and maximum allowable limits for each of these appears in Appendix B. Once cleaned, the resin should be stored in a wide-mouth amber glass container with a Teflon®-lined cap. The resin should be used within two weeks of preparation.

2.2.3 Silica Gel. Indicating type, 6 to 16 mesh. Dry at 175°C (350°F) for 2 hours before using.

2.2.4 Impinger Solutions. As the impingers solutions are often used only for determinations of gas stream water-vapor content, distilled water may be used. If specific inorganic species are to be determined, then other appropriate absorbing solutions must be used. Table 4 presents recommended impinger solutions for collecting specific inorganic species from exhaust gas streams. The Level 1 Procedures Manual (5) should be consulted for further details.

2.3 Materials and Supplies Needed for Sample Recovery.

2.3.1 Methanol/methylene chloride. Distilled-in-glass or pesticide grade methanol and methylene chloride are required as a minimum.

2.3.2 Water. Distilled-deionized water shall be used for rinsing the impingers after transferring any impinger catches that will be analyzed.

2.3.3 Probe Liner, Nozzle and Cyclone/Filter Holder Brushes. Nylon bristle brushes with stainless steel wire handles are required. The probe brush shall have extensions of stainless steel, Teflon® or other inert material equal to the length of the probe. The brushes shall be properly sized and shaped to brush out the probe liner, the nozzle, the cyclones, the filter holder and the organic module. Separate brushes are required for each cyclone and the filter holder to avoid cross-contamination of one particle size fraction by another.

2.3.4 Wash Bottles. Three are needed; Teflon® or glass is required to avoid contamination of organic solvents; Teflon® is preferred because it is unbreakable.

2.3.5 Glass Sample Storage Containers. The containers must be chemically resistant, borosilicate glass bottles, 500 mL or 1,000 mL. Screw cap liners should either be Teflon® or Teflon®-lined and constructed so as to be leak-free and resistant to chemical attack by organic recovery solvents.

2.3.6 Petri Dishes. These must be glass and sealed around the circumference with 2.54 cm (1 in.) Teflon® tape for storage and transport of filter samples.

2.3.7 Graduated Cyclinder and Triple-beam Balance. To measure condensed water to within 1% of the total volume collected. Graduated cylinders must have subdivisions no greater than 1% of their capacity. The material of construction must be glass for measuring the volume of any solution that will be subject to organic analysis. Laboratory triple-beam balances with maximum capacities of 1600 g are capable of weighing to 0.5 gram or better.

2.3.8 Nalgene® Sample Storage Containers. Screw-cap polypropylene or polyethylene containers are necessary for storage of silica gel, and high-density linear polyethylene for storage of the impinger solutions.

2.3.9 Funnels. To aid in recovery of samples for organic analysis, glass funnels are required. Glass or plastic funnels may be used elsewhere but care must be taken to segregate the two types.

TABLE 4. SASS RECOMMENDED IMPINGER SOLUTIONS

Species Removed from Gas Stream	Impinger Solution	Mechanism of Removal
Hydrochloric Acid	0.1 N or weaker* Hydroxide or Sodium Acetate** or Sodium Carbonate**	Neutralization/dissolution
Heavy Metals (volatile and semi-volatile)	0.1 N Nitric Acid	Oxidative dissolution
Sulfur Dioxide	3-30% Hydrogen Peroxide	Oxidative dissolution
Sulfur Trioxide	80% Isopropanol***	Condensation/dissolution

*The use of caustic any stronger will result in the absorption of sufficient carbon dioxide from the stack gas to precipitate carbonate salts that may plug the center stem of one or more of the impingers.

**Sodium acetate and carbonate may be used as more concentrated solutions, provided that their solubility limits are not exceeded. Sodium acetate is a potential interference, however, in analyzing for chloride by ion chromatography.

***To measure the moisture collected in any impinger containing this solution, the solution must be weighed, not measured, as the volumes of water and isopropanol are not additive.

3. Sampling.

3.1 Pretest Preparation.

The probe tips, pitot tubes, dry gas meter, thermocouples, and any thermometers used must be calibrated before and after each field sampling trip according to the procedures outlined in Rom (8). During extended sampling trips where the train will routinely be used more than 10 times, it is strongly recommended that a calibrated orifice, a set of micrometers or vernier calipers, and a standard mercury-in-glass thermometer accompany the sampling system to verify that the calibration of the dry gas meter, probe nozzles, and thermocouples, respectively, have not changed significantly (greater than ± 2%). The aneroid barometer should be calibrated on a daily basis against a mercury barometer when in the laboratory and periodically in the field by consulting the local weather station and correcting for elevation. Detailed calibration procedures are outlined in Section 4, and Vol. III of the EPA Quality Assurance Handbook (9).

Weigh several 700-800 g portions of silica gel in air-tight containers to ± 0.1 g. Record the weight of the silica gel plus the container on the container and in the field sampling preparation notebook.

Holding with blunt-tipped tweezers, hold and check filters visually against light for irregularities, flaws, or pinhole punctures. Label the shipping containers (glass petri dishes) and keep the filters in these containers at all times except during sampling and weighing. The filters, themselves, need not be labelled if strict compliance with the above instruction is ensured. Dessicate the filters with the petri dishes open at 20 ± 5.6°C (68 ± 10°F) and ambient pressure for at least 24 hours and weigh. Thereafter, weigh at intervals of a minimum of 6 hours to a constant weight, i.e., previous weight ± 0.5 mg; record the weight to the nearest 0.1 mg, along with the date and time in the field sampling preparation notebook. Alternatively, unused filters may be oven-dried at 105°C (210°F) for 2 to 3 hours, desiccated for 2 hours, weighed, and weighed thereafter at intervals of 6 hours to a constant weight. At no time, however, may used filters be oven-dried, as exposure to heat will tend to desorb any organic material that has been collected. During each weighing, the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity greater than 50 percent.

Passivate all SASS train parts and sample storage containers, referring to the procedure that appears in Appendix C, adapted from Level 1 (5) requirements. Passivation is required of all new train components and sample storage containers before their initial use in the field. Thereafter, passivation of the train components should be conducted every 6 months when the frequency of tests is once per month or less, and every 3 months when the frequency is between once per week and once per month. If testing is more frequent, passivation should be conducted proportionately more often. Whenever corrosion has occurred, the corrosion must be removed and the passivation repeated. The passivation and rinse solutions should be replaced every fourth use, or discarded weekly.

Assembly and leak-check of the entire train in the laboratory is strongly recommended before any field sampling trip to reveal the need for replacement of gaskets or defective components. The leak check procedure is described in the next section. Substitution of Viton-A gaskets for Teflon® may facilitate meeting the allowable leak rate. In addition, a length of Teflon® tape should be stretched around the circumference (outside) of each flanged connection before placing the ring clamp on as a secondary seal against leakage. Once secured, each ring clamp should be tapped around the circumference to properly seat it.

3.2 Preliminary Field Determinations.

Select the sampling site and remove any accumulated scale and corrosion from the stack access ports. Determine the stack static pressure, temperature, and velocity profile using EPA Method 2(3); a leak check of the pitot lines prior to conducting these measurements is highly recommended. Approximate the moisture content using EPA Method 4 (3) (Approximation Method) or alternate means such as drying tubes, wet bulb/dry bulb or condensation techniques, stoichiometric calculations, or previous experience. Determine the stack gas dry molecular weight by performing an ORSAT or GC/TCD analysis for CO, CO_2, O_2 and N_2 on an average of 3 grab samples taken from either the center of the duct if the duct is smaller than 2 m. (6.6 ft.) in diameter or a point no closer to the stack walls than 1.0 m (3.3 ft) if the duct is larger than 2 m. (6.6 ft.) in diameter.

Select a nozzle size based upon the calculations below, insuring that it will not be necessary to change the nozzle during the sampling run to maintain near isokinetic sampling rates.

Calculation of the Required Nozzle Diameter

(1) First calculate the Average Stack Gas Velocity:

$$(V_s)_{avg} = K_p C_p \left(\sqrt{(\Delta P)} \right)_{avg} \sqrt{\frac{(T_s)_{avg}}{P_s M_s}}$$

where: (V_g) avg = Average stack gas velocity m/sec (ft/sec)

$$K_p = 34.97 \frac{m}{sec} \left[\frac{(g/gmole)\ (mm\ Hg)}{(°K)\ \ mm\ H_2O} \right]^{1/2} \text{ or } 85.48 \frac{ft}{sec} \left[\frac{(lb/lbmole)\ (in.\ Hg)}{°R\ (in\ H_2O)} \right]^{1/2}$$

C_p = Pitot tube coefficient, dimensionless

P = Velocity head of stack gas, mm H_2O (in H_2O)

$(T_s)_{avg}$ = Average stack gas temperature, °K (°R)

P_s = Absolute stack gas pressure, mm Hg (in Hg)

M_s = Molecular weight of stack gas (wet basis), g/g-mole (lb/lb-mole)

(2) Then calculate the required Nozzle Diameter:

$$D_n = Q \sqrt{\frac{(T_s)_{avg}}{(V_s)_{avg} P_s}}$$

where: D_n = Nozzle diameter, mm (inches)

Q = 21.11 for metric (0.831 for English)

$(T_s)_{avg}$ = Average stack gas temperature, °K (°R)

$(V_s)_{avg}$ = Average stack gas velocity, m/sec (ft/sec)

P_s = Absolute stack gas pressure, mm Hg (in. Hg)

Select a suitable probe length such that one or more points of average velocity can be sampled. Determine the total length of sampling time by comparing the anticipated average sampling rate to the volume requirement of 30 dscm (approximately 1000 dscf).

The anticipated Average Sampling Rate is calculated as follows:

$$Q_{mo} = (1-B_{ws})Q_{st} \frac{P_{st}(T_m)_{avg}}{P_m (T_{st})}$$

where: Q_{mo} = Flow rate through orifice at meter conditions (dry), m^3/min (ft^3/min)

B_{ws} = Volume fraction of water vapor in the gas stream, dimensionless

Q_{st} = Design sampling flowrate for SASS, 0.113 scmm (4.0 scfm)

P_{st} = Standard pressure, 760 mm Hg (29.92 in. Hg)

$(T_m)_{avg}$ = (estimated) Average gas temperature at the dry gas meter, °K (°R)

P_m = Absolute meter pressure, mm Hg (in. Hg)

$$P_m = P_b + \frac{(\Delta H) \text{ est. avg.}}{13.6}$$

where: P_m = Absolute meter pressure, mm Hg (in. Hg)

and (ΔH) est. avg. = Estimated average ΔH across orifice, typically 76.2-101.6 mm H_2O (3-4 in. H_2O)

P_b = Barometric pressure (corrected), mm Hg (in. Hg)

T_{st} = Standard temperature, 293.3°K (528 °R)

Using these results, obtain the approximate sampling time by dividing the required sample volume by the estimated sampling flowrate.

Finally, calculate the Orifice Pressure Drop needed to maintain near-isokinetic sampling conditions from the equation.

$$\Delta H_i = \frac{P_m}{(T_m)_{avg}} \left[\frac{0.1924\ Q_{mo}}{J_i D_{oi}^2}\right]^2$$

where: ΔH_i = Required ΔH across the orifice, mm H_2O (in. H_2O)

P_m = Absolute meter pressure, mm Hg (in. Hg) (see previous equation)

$(T_m)_{avg}$ = (estimated) Average gas temperature at the dry gas meter, °K (°R)

J_i = Orifice coefficient for orifice "i" (1)

D_{oi} = Orifice diameter, mm (inches (1))

It is desirable, but not required, to sample more than one point of average velocity during a SASS run. Allocate equal intervals of the total sampling time estimated above to each sampling point chosen, if more than one point is sampled.

3.3. Preparation of the Collection Train

An integral part of preparing the collection train is securing sufficient electrical power to operate for an extended period of time without interruption. Three separate circuits, two thirty-ampere (30-amp) and one twenty-ampere (20-amp), are required. It is strongly recommended that one sampling pump and one control box power cord (probe heater) be placed on one of the 30-amp circuits, and the other sampling pump and control box power cord (oven heater and temperature readout) be placed on the other 30-amp circuit. The organic module coolant pump and temperature controller should be placed on the 20-amp circuit.

During assembly of the train, keep the inner surfaces of each component covered until it is integrated into the system and sampling is about to begin. Fill the sorbent trap section of the organic module with approximately 130 g of clean adsorbent resin. To avoid contamination, the trap should be placed upon a clean surface (i.e., aluminum foil rinsed with methylene chloride and air-dried); gloves should be worn as it is being filled. Pack the trap uniformly to eliminate potential channeling. When freshly cleaned, many adsorbent resins carry a static charge causing the resin beads to cling to the trap walls. This may be minimized by filling the trap in the presence of an ionizing source such as ^{210}Polonium, which acts as an antistat. Commercial antistatic devices are available from the NRD Corp. Grand Island, NY, or the 3-M Co., Inc., St. Paul, MN.

Place 500 mL of distilled water or other appropriate solution into the first and second impingers, leave the third impinger empty and place a preweighed portion of silica gel into the fourth. The choice of impinger solutions depends upon whether these will be used to collect selected inorganic species or to simply condense water vapor from the gas stream to measure percent moisture (see Table 4).

Using blunt-tipped tweezers, place a tared filter into the filter holder. Insure that the filter is centered and the gasket properly placed to prevent the gas stream from bypassing the filter.

On the probe, mark the locations of the chosen sampling points with heat-resistant tape or paint.

The stepwise procedure for assembly of the train follows:

1. Place the oven on a table or rollers that will be used as a support throughout the run.

2. Assemble the three cyclones, using the vortex breaker in the 10-um cyclone only. Do not use the vortex breakers supplied with the 3 um and 1 um cyclones.

3. Attach the filter holder to the outlet of the 1 um cyclone and place the cyclones and filter holder together in the oven. Preheat a spare filter holder, if available, containing a tared filter on the oven floor; cover the holder openings with aluminum foil. A spare filter holder is not supplied with the SASS, but is a recommended accessory for saving sampling time.

4. Attach the probe to the oven and to the 10 um cyclone.

5. Place the impingers in the tray in the impinger case and make the appropriate interconnections.

6. Connect the organic module inlet to the filter housing outlet and the organic module outlet to the first impinger inlet.

7. Connect the vacuum pumps in parallel to the fourth impinger outlet.

8. Connect all temperature sensors and power lines to the control unit. Check temperature indicators and controllers at ambient temperature.

9. Check the coolant level in the coolant reservoir to insure that it is within 1.3 cm (½ in.) of the top of the reservoir. (This check must always be performed before supplying power to the gas conditioning system). If the coolant level is acceptable, activate the gas conditioning system. Begin monitoring both the XAD-2® and the gas conditioning system temperatures. Insure proper gas conditioning system temperature before proceding and again before any sampling is initiated. IT IS EXTREMELY IMPORTANT THAT THE XAD-2®RESIN TEMPERATURE NEVER EXCEED 50°C, AS THERMAL DECOMPOSITION WILL OCCUR. During testing, the XAD-2® temperature must not exceed 21°C (70°F) for efficient capture of the semivolatile organic species of interest.

10. Heat oven and probe to 204°C (400°F).

11. Run gas flow leak-check.

3.4 Leak Check Procedures.

Pretest and post-test leak checks, and leak-checks before and after each component change are required to insure that leakage does not occur while sampling as a result of an oversight in preparing the collection train or a defective train component.

3.4.1 Pretest Leak Check. The following instructions outline the pretest leak-checking procedure:

- Open the isolation ball valve and plug the inlet to the probe with a rubber stopper or appropriate air-tight cap.

- Start the pumping system with the fine adjust valves fully open and the coarse valves completely closed. Partially open the coarse valves and slowly close the fine adjust valves until a vacuum of 127 mm. Hg (5 in. Hg) is reached. Do not reverse the direction of the fine adjust valves as backflushing of the impinger solutions into each other or the organic module will result. If the desired vacuum is exceeded, either leak-check at the higher vacuum or terminate the leak-check and begin again. Allow the system to equilibrate and measure the leakage rate. The allowable leak rate for the SASS train is 0.0014 m^3/min (0.05 ft^3/min) at this vacuum. Close the isolation ball valve and evacuate the train to 381 mm. Hg (15 in. Hg). The leak rate through the back half of the train should be less than 0.0014 m^3/min (0.05 ft^3/min) at this vacuum.

- When the leak-check is complete, slowly remove the plug from the probe tip and then slowly open the isolation ball valve.

- When the vacuum drops to 127 mm Hg (5 in Hg) or less, immediately close both coarse control valves together. Switch off the pumping system and reopen the fine adjust valves. The fine adjust valves should not be opened until the coarse valves have been closed.

3.4.2 Leak Checks During Run. A leak check of the SASS is necessary both before and after a component is changed. Immediately after sampling is interrupted and before the change is made, the entire leak check should be conducted at the highest vacuum recorded for the time period the given component was used. If the leakage rate is found to be no greater than 0.0014 m^3/min (0.05 ft^3/min), the results are acceptable. If however, a higher leakage rate is obtained, the tester shall attempt to terminate the run at this point and repeat it. If the run cannot be repeated, the tester shall record the leakage rate and correct the sample volume as shown in Section 5.2; the data shall then be considered of questionable reliability.

3.4.3 Post-test Leak-Check. A post-test leak check of the SASS is mandatory following the termination of sampling, when the probe can be safely handled. The entire leak check should be conducted at the highest vacuum recorded since the last component change. If the leakage rate is found to be no greater than 0.0014 m^3/min (0.05 ft^3/min), the results are acceptable. If however, a higher leakage rate is obtained, the tester shall use the criteria in Section 3.4.2 to determine whether or not the run will be repeated.

3.5 Sample Collection.

Constant monitoring of train operations before, during and after the particulate run are essential in maintaining sample integrity. Listed below are sample collecting guidelines; Vol. III of the EPA Quality Assurance Handbook (9) should also be referred to for additional guidelines.

1. With the coarse valves closed and fine adjust valves open, turn on the vacuum pumps and allow them to warm up. As the probe and oven are heating, prepare a SASS run data sheet as shown in Appendix C. Barometric pressure data should be recorded at the beginning and end of the run at a minimum; once per hour is preferred.

2. When operating temperatures have been reached, one or two persons must place the probe in the duct at the first designated sampling point, while another simultaneously turns on the vacuum pumps, adjusts the sampling flowrate to achieve the calculated ΔH_i, and starts the elapsed timer. If, however, the gas stream is under a medium or high negative pressure, it becomes extremely important to start the vacuum pumps just before placing the probe in the gas stream, and to continue to operate the pumps until just after the probe has been removed from the gas stream. This will eliminate the possibility of lifting of the filter or back-flushing of the filter and cyclone particulate catches at any time.

3. Seal the sampling port around the probe to prevent introduction of dilution air at this point. Record the clock time of the start of the test.

4. Place the integrated fixed gas bag or bulb sampling probe into the gas stream at the appropriate location and begin sampling. Collect 2 samples during the SASS run; record the initial and final clock times of each integrated fixed gas sample.

5. Monitor and maintain all temperatures and the calculated H, and record the data at equal intervals of 10-15 minutes.

6. Add crushed ice to the impinger section and drain excess water, as necessary.

7. Without interrupting sampling, drain the condensate initially, every 30-45 minutes, and afterward, as necessary. Insure that the vessel into which the condensate is drained forms an air tight system with the reservoir using a connecting Teflon line, and is placed well below the level of the reservoir itself. To drain the reservoir, close the isolation ball valve and open the drain valve. Allow the system to evacuate for 10-20 secs. Carefully open the isolation valve. The condensate should siphon from the reservoir into the storage vessel. Close the drain valve when the siphoning action ceases.

8. Replace the filter when it becomes impossible to maintain near-isokinetic sampling rates, but not more frequently than every 20-30 min. Always terminate/initiate sampling by closing/opening the coarse pump valves and then the fine adjust valves. A spare filter holder and filter, if available, should be preheating in the oven at all times. Conduct leak-checks before and after changing the filter. Follow the instructions in Step 2 concerning removal and reintroduction of the probe into the duct. Record the clock time and dry gas meter reading whenever sampling is interrupted.

9. While sampling is interrupted, also check the 1 um cyclone reservoir for remaining capacity. Tap the outside of the upper chamber so that any loose particulate material falls into the cup below. Remove the ring clamp and carefully separate the cup from the upper chamber; visually inspect and transfer the contents to a clean sample container. Replace the cup and the ring clamp. Bring the oven up to the specified operating temperature, leak-check the train and recommence sampling.

10. When replacing a component, start and stop the fixed gas sampling concurrently with the SASS sampling; record the clock time whenever sampling is interrupted.

11. Upon collection of the required 30 dscm (1000 dscf), remove the probe from the gas stream and shut down the pumps as previously instructed. Record the final dry gas meter reading and clock time; turn off all heaters. Conduct the post-test leak check when the probe tip can be safely handled. Do not cap the probe while initially cooling; this will create a vacuum inside which, when released, will cause disruption of the cyclone and filter particulate catches. Instead, use aluminum foil to cover probe openings. Before the probe is transported, secure the aluminum foil covers with a rubber cap. Leak check the pitot lines per EPA Method 2 (3) to validate velocity head data.

3.6 Sample Recovery.

3.6.1 Disassembly of the SASS. After the post-test leak check, the train is disassembled and transported to the prepared work area as follows:

1. Leaving the fan operating, open the oven door to expedite cooling. When the probe can be safely handled, disconnect it from the 10 um cyclone inlet. Wipe off external particulate matter near the probe tip and place a cap over each end. The probe must remain level throughout this procedure.

   Care must be taken to avoid tightly capping train components as they are cooling from stack or oven temperatures. This will eliminate the possibility of creating a vacuum inside which, when released, may disrupt and backflush the cyclone and filter particulate catches into one another.

2. Disconnect the line joining the filter outlet to organic module and cap off the 10 um cyclone inlet, the filter holder outlet and, the inlet of the line just disconnected from the filter holder outlet.

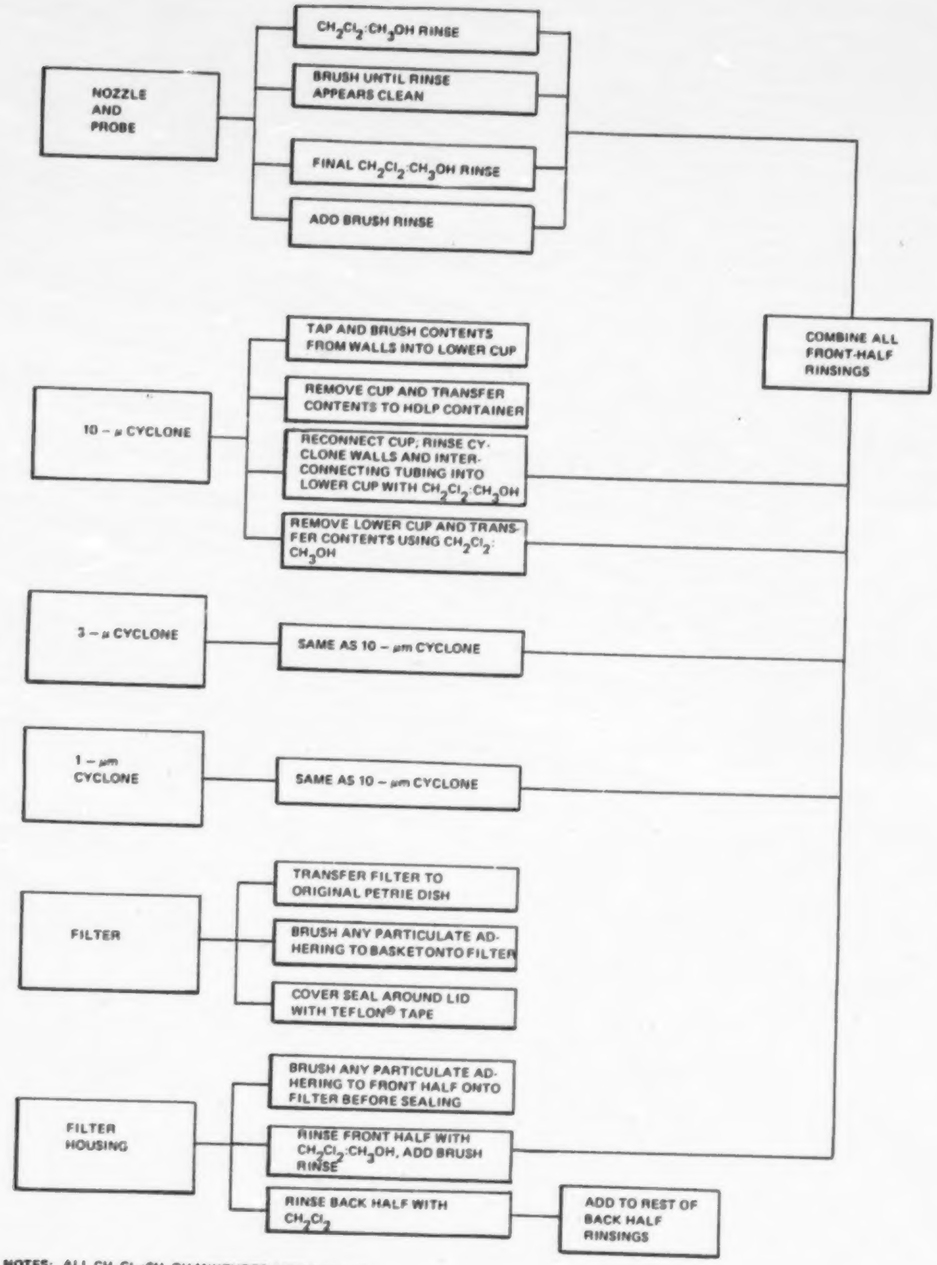
   Disconnect the filter holder and cap the inlet. Set aside with the inlet facing upward. Cap the outlet of the 1 um cyclone. The cyclones must remain upright throughout this procedure. The cyclones can now be disconnected from one another or moved to the recovery area as a single unit.

3. Disconnect the line joining the organic module to the impinger system at the organic module outlet. Cap the organic module outlet.

4. Disconnect the silica gel impinger outlet from the vacuum line to the pumps; cap off the first impinger inlet and the fourth impinger outlet.

3.6.2 Sample Handling and Transfer. The sample handling and transfer procedures outlined in this section are based on the Level 1 (5) procedures. The flow diagrammatic representation of the sample recovery procedures are shown in Figures 10, 11, and 12. The quality assurance/quality control procedures that must be followed during sample recovery are provided in Vol. III of the EPA Quality Assurance Handbook (9). An example coding format for SASS samples follows in Table 5.

3.6.3 Nozzle, Probe, Cyclones and Filter Recovery. The step-by-step procedures for the recovery of particulate material collected in the nozzle, probe and cyclones, and on the filter are detailed below:


NOZZLE AND PROBE
CH_2Cl_2:CH_3OH RINSE
BRUSH UNTIL RINSE APPEARS CLEAN
FINAL CH_2Cl_2:CH_3OH RINSE
ADD BRUSH RINSE
COMBINE ALL FRONT-HALF RINSINGS
10 – μ CYCLONE
TAP AND BRUSH CONTENTS FROM WALLS INTO LOWER CUP
REMOVE CUP AND TRANSFER CONTENTS TO HDLP CONTAINER
RECONNECT CUP; RINSE CYCLONE WALLS AND INTERCONNECTING TUBING INTO LOWER CUP WITH CH_2Cl_2:CH_3OH
REMOVE LOWER CUP AND TRANSFER CONTENTS USING CH_2Cl_2:CH_3OH
3 – μ CYCLONE
SAME AS 10 – μm CYCLONE
1 – μm CYCLONE
SAME AS 10 – μm CYCLONE
FILTER
TRANSFER FILTER TO ORIGINAL PETRIE DISH
BRUSH ANY PARTICULATE ADHERING TO BASKETONTO FILTER
COVER SEAL AROUND LID WITH TEFLON® TAPE
FILTER HOUSING
BRUSH ANY PARTICULATE ADHERING TO FRONT HALF ONTO FILTER BEFORE SEALING
RINSE FRONT HALF WITH CH_2Cl_2:CH_3OH, ADD BRUSH RINSE
RINSE BACK HALF WITH CH_2Cl_2
ADD TO REST OF BACK HALF RINSINGS

NOTES: ALL CH_2Cl_2:CH_3OH MIXTURES ARE 50:50 V/V.
ALL CONTAINERS FOR SAMPLES FOR ORGANIC ANALYSIS MUST BE GLASS.
USE TEFLON® OR GLASS WASH BOTTLES; TEFLON® IS PREFERRED.

Figure 10: SASS sample handling and transfer: nozzle, probe, cyclones and filter

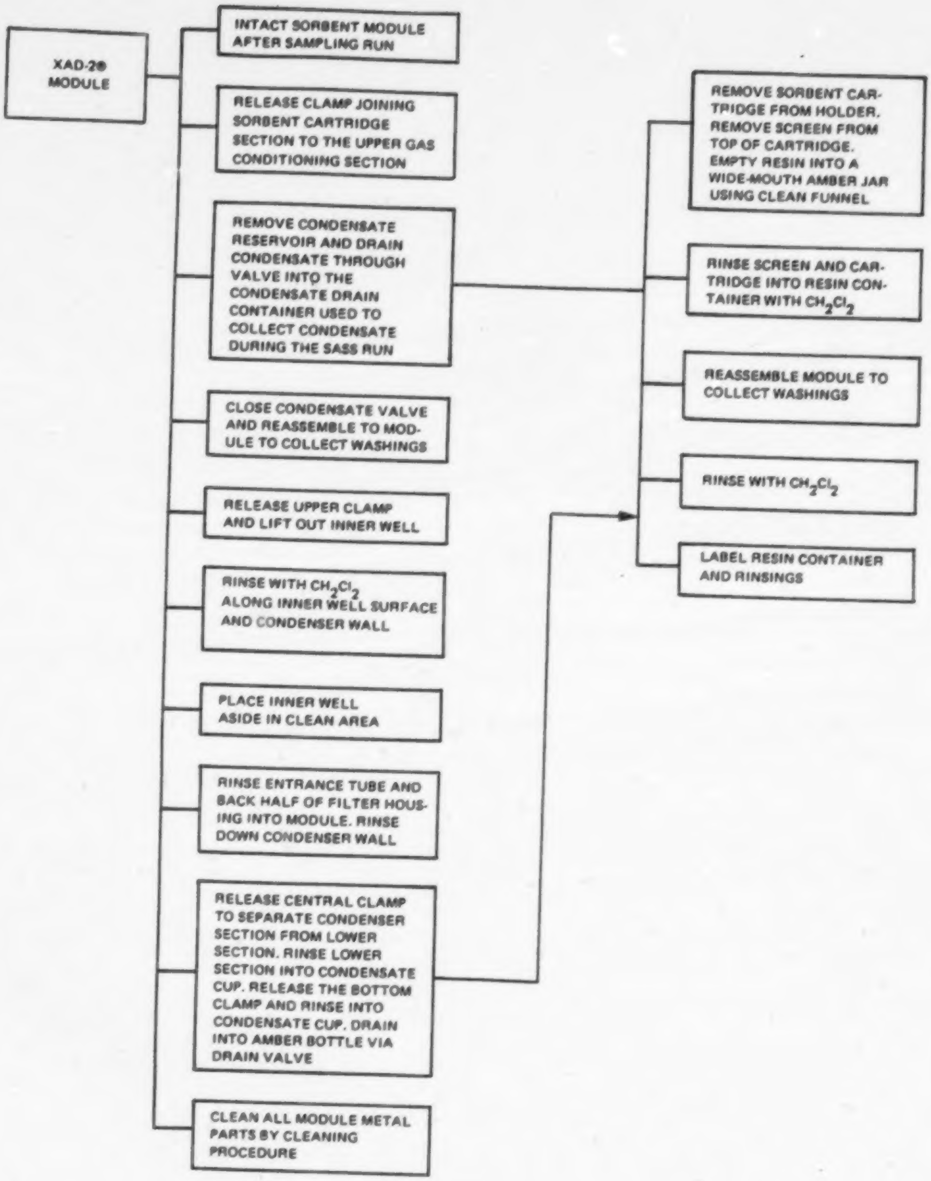
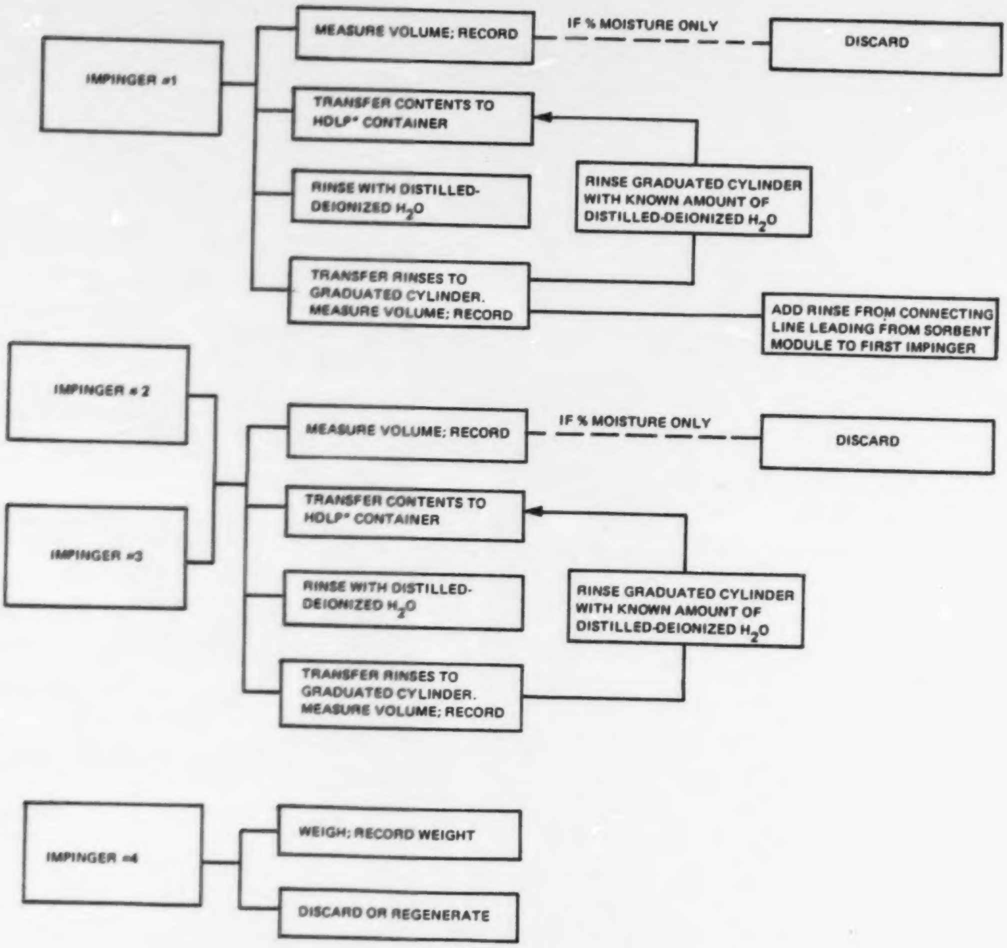

XAD-2® MODULE
INTACT SORBENT MODULE AFTER SAMPLING RUN
RELEASE CLAMP JOINING SORBENT CARTRIDGE SECTION TO THE UPPER GAS CONDITIONING SECTION
REMOVE CONDENSATE RESERVOIR AND DRAIN CONDENSATE THROUGH VALVE INTO THE CONDENSATE DRAIN CONTAINER USED TO COLLECT CONDENSATE DURING THE SASS RUN
CLOSE CONDENSATE VALVE AND REASSEMBLE TO MODULE TO COLLECT WASHINGS
RELEASE UPPER CLAMP AND LIFT OUT INNER WELL
RINSE WITH CH2Cl2 ALONG INNER WELL SURFACE AND CONDENSER WALL
PLACE INNER WELL ASIDE IN CLEAN AREA
RINSE ENTRANCE TUBE AND BACK HALF OF FILTER HOUSING INTO MODULE. RINSE DOWN CONDENSER WALL
RELEASE CENTRAL CLAMP TO SEPARATE CONDENSER SECTION FROM LOWER SECTION. RINSE LOWER SECTION INTO CONDENSATE CUP. RELEASE THE BOTTOM CLAMP AND RINSE INTO CONDENSATE CUP. DRAIN INTO AMBER BOTTLE VIA DRAIN VALVE
CLEAN ALL MODULE METAL PARTS BY CLEANING PROCEDURE
REMOVE SORBENT CARTRIDGE FROM HOLDER. REMOVE SCREEN FROM TOP OF CARTRIDGE. EMPTY RESIN INTO A WIDE-MOUTH AMBER JAR USING CLEAN FUNNEL
RINSE SCREEN AND CARTRIDGE INTO RESIN CONTAINER WITH CH2Cl2
REASSEMBLE MODULE TO COLLECT WASHINGS
RINSE WITH CH2Cl2
LABEL RESIN CONTAINER AND RINSINGS

Figure 11. SASS sample handling and transfer: organic module section.


IMPINGER #1
MEASURE VOLUME; RECORD
IF % MOISTURE ONLY
DISCARD
TRANSFER CONTENTS TO HDLP* CONTAINER
RINSE WITH DISTILLED-DEIONIZED H_2O
RINSE GRADUATED CYLINDER WITH KNOWN AMOUNT OF DISTILLED-DEIONIZED H_2O
TRANSFER RINSES TO GRADUATED CYLINDER. MEASURE VOLUME; RECORD
ADD RINSE FROM CONNECTING LINE LEADING FROM SORBENT MODULE TO FIRST IMPINGER
IMPINGER # 2
IMPINGER #3
MEASURE VOLUME; RECORD
IF % MOISTURE ONLY
DISCARD
TRANSFER CONTENTS TO HDLP* CONTAINER
RINSE WITH DISTILLED-DEIONIZED H_2O
RINSE GRADUATED CYLINDER WITH KNOWN AMOUNT OF DISTILLED-DEIONIZED H_2O
TRANSFER RINSES TO GRADUATED CYLINDER. MEASURE VOLUME; RECORD
IMPINGER #4
WEIGH; RECORD WEIGHT
DISCARD OR REGENERATE

*HDLP = HIGH-DENSITY LINEAR POLYETHYLENE.

Figure 12. SASS train sample handling and transfer: impinger train

TABLE 5. EXAMPLE CODING FORMAT FOR SASS SAMPLES

Sample Code	Container	Size	Sample Description
1C	Amber glass	100 mL, wide-mouth	1 um Cyclone catch
3C	Amber glass	100 mL, wide-mouth	3 um Cyclone catch
10C	Amber glass	100 mL, wide mouth	10 um Cyclone catch
PF-a,b,c..	Glass petri dish	6 in. diameter	Particulate filter(s)
FHR	Clear glass*	1L	Front-half rinse (50:50 methanol/ methylene chloride)
SMB	Clear glass*	1L	Solvent mix blank (50:50 methanol/methylene/ chloride)
BHR	Clear glass*	1L	Back-half rinse (methylene chloride)
SB	Clear glass*	1L	Solvent blank (methylene chloride)
XAD	Amber glass	500 mL	XAD-2® resin and rinse
XADB	Amber glass	500 mL	XAD-2® resin blank
CD	Amber glass	1L	Condensate collected in knockout
I1	HDLP**	1L	First impinger catch
I1B	HDLP**	1L	First impinger blank (Appropriate collecting solution)
I2,3	HDLP**	1L	Second and third impinger catches
I,2,3B	HDLP**	1L	Second and third impinger blank (Appropriate collecting solution)

*must be clear to allow tester to verify when components have been "rinsed clean"; cover with aluminum foil to protect sample from light during shipment.

**HDLP = High-Density linear polyethylene

1. Carefully transfer the filter from the filter housing to its original glass petri dish; a pair of clean blunt-tipped tweezers and a flat spatula should be used for handling the filter. Using a clean nylon-bristled brush, add any particulate material from the front half of the filter housing to the petri dish; seal the petri dish around the circumference with 2.54 cm (1-in.) wide Teflon tape; store with the collected particulate material facing upward. If it is necessary to fold the filter for transport, fold inward so that the particulate cake is inside the fold. The filter must be stored in a glass container and the use of aluminum foil to wrap the filter is not permitted.

   Clean the inside of the front half of the filter holder and cyclone/cyclone flask, if used, by rubbing the surfaces with a nylon bristle brush and rinsing with methanol/methylene chloride (50:50) mixture. Rinse each surface at least three times to remove visible particulate. Make a final rinse of the brush and filter holder. Carefully rinse out the glass cyclone and cyclone flask (if needed). Brush and rinse any particulate material adhering to the inner surfaces of these components into the front-half rinse sample. After all solvent washings and particulate matter have been collected, tighten the sample container lid so that solvent will not leak out during shipment to the laboratory. Mark the height of the fluid level to determine if leakage occurs during transport. Label the container clearly to identify its contents. Rinse the back half of the filter holder in the same manner into a separate container with methylene chloride only. Combine this rinse with the organic module section rinses described in the next subsection.

2. Tap and brush any particulate material adhering to the walls of the upper chamber of the 1 um cyclone into the lower cup; remove the cup and quantitatively transfer the bulk contents to a wide-mouth amber glass jar. Rinse the brush with methanol/methylene chloride (50:50 mixture) into the probe rinse container.

3. Recover the contents of the 3 um cyclone in the same manner using a separate wide-mouth amber glass jar.

4. Recover the contents of the 10 um cyclone in the same manner using a separate wide-mouth amber glass jar.

5. Reconnect the lower cups of each cyclone and rinse any particulate material adhering to the walls (until the walls appear clean) down into the cups with methanol/methylene chloride (50:50 mixture). Remove the lower cups and transfer the contents to the probe rinse container. Rinse the interconnecting tubing among the cyclones into the probe rinse in the same manner.

6. Carefully remove the probe nozzle and clean the inside surface by rinsing with methanol/methylene chloride (50:50 mixture) from a wash bottle and brushing with a nylon-bristle brush. Brush until

the rinse shows no visible particles; make a final rinse of the inside surface.

With two people supporting the probe in an inclined position, rinse with methanol/methylene chloride (50:50 mixture) by rotating the probe while spraying solvent into the upper end and allowing the lower end to drain into the sample container. Follow with brushing from the upper to the lower end and rinsing. Push the brush through the liner with a twisting action; insure that the sample container is placed under the lower end. Brush until the rinse appears clean; perform a final rinse. Inspect the inner surface of the liner for cleanliness. Rinse any particulate material remaining on the brush into the sample container.

7. Clearly label all container(s) and cover each label completely with transparent tape. Mark the liquid levels and store the liquid samples on ice.

3.6.4 Condenser, Sorbent Module and Condensate Reservoir Recovery. Sample recovery of the entire organic module may be conducted independently from the previous steps. The step-by-step procedure for recovery of this component is given below:

1. Rinse a 0.09 square meter (1 $ft.^2$) of aluminum foil (dull side) with methylene chloride and allow to air dry.

2. Release the clamp joining the XAD-2® cartridge section to the upper gas conditioning system (second clamp), remove the XAD-2® cartridge from the holder and place upon the clean aluminum foil.

   GENTLY pry loose or unscrew (depending upon the design) the ring securing the fine mesh screen on the top of the cartridge. Remove the screen and quantitatively transfer the XAD-2® to a clean amber glass jar. A large glass funnel should be used for the transfer. Rinse the inner surfaces of the cartridge and the funnel with methylene chloride as necessary to remove adhering XAD-2®. Any XAD-2® that escapes onto the aluminum foil should be retrieved and added to the sample.

3. Replace the screen on the cartridge, reinsert the cartridge into the module and reassemble the module. One person can accomplish this task by butting the lower section in its proper sealing position up against the upper section while securing the ring clamp. One or more wooden spacers approximately 1.3 cm (½ in.) thick are suggested for this purpose.

4. Open the condensate reservoir valve and drain the remaining condensate into the condensate storage container. Measure and record the volume and pH.

5. Disconnect the Teflon® line from the condensate reservoir to the condensate storage vessel and transfer the entire condensate to one or more appropriately-sized sample storage containers.

6. Insure that the condensate reservoir valve is closed, release the upper clamp, and lift the inner well halfway out of the module. Rinse the inner well with methylene chloride down into the organic module so that the rinse travels down the module and into the condensate collector. Then remove the well entirely and place to one side on a clean surface (aluminum foil pre-rinsed with methylene chloride). Rinse the entrance tube into the organic module interior; rinse the condenser wall allowing solvent to flow down through the system and collect in the condensate reservoir cup.

7. Release the central clamp again and separate the lower section (XAD-2® cartridge holder and condensate cup) from the upper.

8. Lift the empty XAD-2® cartridge halfway out of the midsection and rinse the outer surface down into the condensate cup. Remove the cartridge completely to a clean surface (aluminum foil rinsed with methylene chloride).

9. Rinse the empty XAD-2® section with methylene chloride into the condensate cup. Open the condensate reservoir valve and drain into a clean sample storage container (wide-mouth amber glass jar).

10. Rinse the condensate reservoir with methylene chloride and combine the rinse with the rinse from above.

11. Clearly label the containers and cover each label completely with transparent tape. Mark the liquid levels and store the liquid samples on ice.

3.6.5 Impinger Train and Silica Gel Recovery. Sample recovery from the impingers may also be accomplished independently of the other two sections of the SASS. The procedure is described below:

1. Measure the volume of liquid in the first impinger with a graduated cylinder.

2. Rinse the line connecting the organic module to the first impinger with distilled-deionized water; transfer the rinse to the same graduated cylinder. Rinse the impinger twice more with distilled-deionized water, combining all rinses in the graduated cylinder. Measure the total rinse volume and add to the sample. Rinse the graduated cylinder with a known amount of distilled-deionized water and add to the sample. Record all volumes on the sample recovery sheet.

3. Clearly label the container(s) and cover each label completely with transparent tape. Mark the fluid levels and store liquid samples on ice.

4. Measure and record the combined volume of liquid in the second and third impingers in a large (1 L) graduated cylinder; transfer to a clean Nalgene® high-density linear polyethylene (HDLP) sample storage container.

5. Rinse the line connecting the first and second impinger into the second impinger and the line connecting the second and third impinger into the third impinger. Transfer the rinses to the same graduated cylinder. Rinse each impinger twice again with distilled-deionized water, combining all rinses in the graduated cylinder.

   Measure and record the combined rinse volume and add to the sample. Rinse the graduated cylinder with a known amount of distilled water and add to the sample. Record this additional rinse volume and add to the impinger rinse volume above.

6. Clearly label the sample container(s) and cover each label completely with transparent tape. Mark the fluid levels and store the liquid samples on ice.

7. Transfer the silica gel from the fourth impinger to its original container. Weigh to the nearest 0.1 gram on a triple-beam balance, and record the weight obtained. Discard or regenerate.

3.6.6 Sample Preparation for Shipment. Prior to shipment, recheck all sample containers to insure that the caps are well secured. Seal the lids of all Nalgene® HDLP containers around the circumference with vinyl tape and those of glass containers with Teflon® tape. Ship all liquid samples upright on ice; ship all particulate filters unrefrigerated with the particulate catch facing upward.

4. Calibration.

All calibration results should be recorded in the Calibration/Field Preparation Record. Example formats for recording the data appear in Appendix C.

4.1 Probe Nozzles.

Probe nozzles must be calibrated before each initial use in the field. Using vernier calipers or micrometers, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Perform three separate measurements using different diameters; obtain the average of the three measurements. The difference between the high and low measurement results must not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they must be reshaped, sharpened, and recalibrated before reuse. Recalibration of the nozzle is strongly recommended before each run in gas streams that are highly corrosive as the nozzle diameter may be changing slightly from one run to the next. Each nozzle must be permanently and uniquely identified.

4.2 Pitot Tube.

If the Type S pitot tube conforms to the construction specifications (and face openings are not visibly nicked, dented, or corroded, and the pitot tube/probe assembly meets the intercomponent spacings outlined in EPA Method 2 (3)), pitot tube calibration is not necessary to meet federal and many state testing requirements; a correction coefficient may be assigned in these cases. Some states, however, require that, once used, pitot tubes be calibrated in a wind tunnel. In either instance, pitot tube face openings must be visually inspected before each run to insure that there has been no change in appearance since their construction or most recent calibration.

4.3 Metering System.

Before each initial use in the field, the metering system shall be calibrated using a standard bell prover of the proper size. A bell prover is recommended for this procedure because the displacement volume of commercially available wet test meters is typically insufficient. A meter stick should be used to indicate the distance travelled by the inner tank during the measurement. Figure 13 illustrates a suitable arrangement for the calibration. It is recommended that the dry gas meter be adjusted until the ratio of the dry gas meter volume to the standard bell prover volume equals 1.00 ± 0.01 to insure that the calculated ΔH_1 will result in near-isokinetic sampling rates. The calibration procedure follows:

1. Perform both a positive (pressure) and a negative (vacuum) leak check of the metering system. For the negative leak check, include only the orifice Magnehelics®, dry gas meter and two vacuum pumps by removing the vacuum line connecting the fourth impinger to the vacuum pumps at the common side of the pump inlet tee, and replacing the line with a plain-end male quick connect. Tightly cap this end and leak check in the manner outlined in Section 3.

   For the positive leak check, connect a short length of rubber tubing to the "gas exhaust" port on the SASS control module; disconnect and vent the low side of the orifice Magnehelic®; close off the low-side of the orifice Magnehelic®; close off the low-side orifice tap; pressurize the system to 13-18 cm. H_2O (5-7 in. H_2O) by blowing into the rubber tubing; pinch off the tubing and observe the Magnehelic® for one minute; the Magnehelic® reading must remain unchanged during that time period. Any loss of Magnehelic® pressure indicates a leak that must be corrected.

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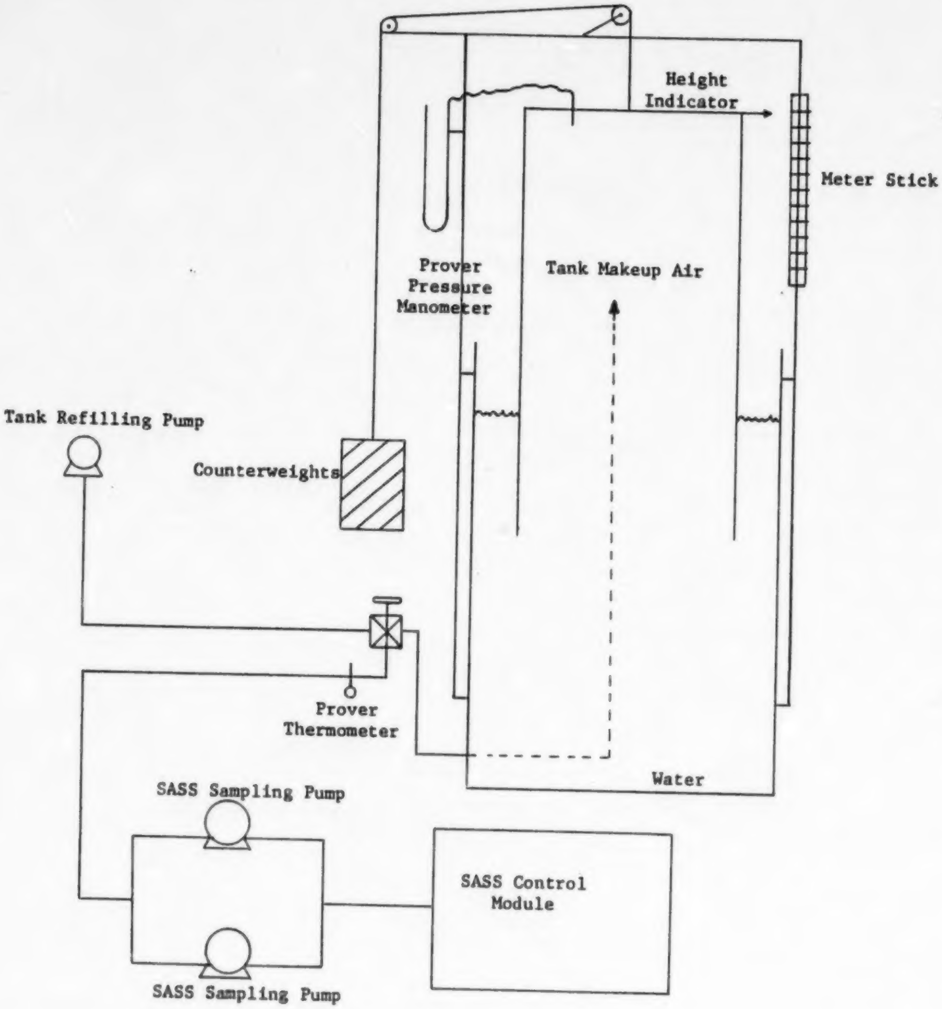
Height Indicator
Meter Stick
Prover Pressure Manometer
Tank Makeup Air
Tank Refilling Pump
Counterweights
Prover Thermometer
Water
SASS Sampling Pump
SASS Control Module
SASS Sampling Pump

Figure 13. Schematic diagram of standard Bell Prover arrangement for SASS dry gas meter calibration.

2. Upon obtaining satisfactory leak checks, connect the metering system to the standard bell prover.

3. Using the control box Magnehelic® indicator, set the pumping rate corresponding to a ΔH of 2.5 cm H_2O (1 in H_2O). Turn the pumps off using the switches.

4. Record the initial temperature and pressure of the bell prover and the initial temperature and reading of the dry gas meter. Record the barometric pressure every hour.

5. Disconnect the metering system and pump the inner tank of the bell prover to a convenient height. Reconnect the metering system and record the height.

6. Start the pumps and a stopwatch simultaneously; evacuate the tank for 3 minutes.

7. After 3 minutes, turn off the pumps using the switches. Record the final inner tank height, the final dry gas meter volume and temperature, and the bell prover final temperature and pressure.

8. Repeat steps 3-7 using ΔH settings of 5.1, 10.2, and 15.3 cm H_2O (2, 4 and 6 in. H_2O).

9. Duplicate the entire procedure as a check; repeat the entire procedure after each adjustment of the dry gas meter.

10. Calculate the Dry Gas Meter Correction Coefficient, the ratio of the volume of gas measured by the dry gas meter to the standard bell prover, both corrected to standard conditions and on a dry basis. The ratio reduces to:

$$Y = \frac{V_{pvr(std)}}{V_{dgm(std)}} = \frac{V_{pvr} P_{pvr} T_{dgm}}{V_{dgm} P_{dgm} T_{pvr}}$$

where:

Y = Dry gas meter correction coefficient, dimensionless

$V_{dgm(std)}$ = Volume of gas measured by the dry gas meter on a dry basis, corrected to standard conditions, dscm (dscf)

$V_{pvr(std)}$ = Volume of gas measured by the standard bell prover on a dry basis, corrected to standard conditions, dscm (dscf)

V_{dgm} = Volume of gas measured at dry gas meter conditions, m^3(ft^3)
= (final volume reading)-(initial volume reading)

V_{pvr} = Volume of gas measured at standard bell prover conditions, $m^3(ft^3)$

V_{pvr} = K_{pvr} x (difference in meter stick height readings)

where: K_{pvr} = number of cubic feet of air displaced represented by each cm of movement along the meter stick, m^3/cm (ft^3/cm).

P_{dgm} = Absolute meter pressure, mm. Hg (in. Hg)
= barometric pressure + $\Delta H/13.6$

P_{pvr} = Absolute prover pressure, mm. Hg (in.Hg)
= Barometric Pressure $- \dfrac{(\Delta P)\text{ prover manometer}}{13.6}$

T_{pvr} = Absolute bell prover temperature, °K(°R)

T_{dgm} = Absolute dry gas meter temperature °K(°R)

11. Calculate the Orifice Constants using the following equations:

(a) $$Q_{mo} = (1-B_{ws})Q_{std}\left[\frac{P_{std}T_{m(avg)}}{P_mT_{std}}\right]$$

where: Q_{mo} = Sampling flowrate at orifice, (dry) m^3/min (ft^3/min)

B_{ws} = Proportion by volume of water in ambient air, dimensionless

Q_{std} = Standard sampling flowrate for SASS, (wet) .113 scmm (4.0 scfm)

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg)

$T_{m(avg)}$ = Average meter temperature °K, (°R)

P_m = Absolute meter pressure (barometric pressure + $\Delta H/13.6$), mm Hg (in. Hg)

T_{std} = Standard temperature, 293.3°K (528 °R)

(b) $$J_i = \frac{Q_{mo}}{A_{oi}}\left[\frac{T_{m(avg)}}{P_mM_m}\ R\Delta H_i\ 2\ g_c\right]^{-\frac{1}{2}}$$

where: J_i = Orifice coefficient for orifice "i"

Q_{mo} = Sampling flowrate at orifice, m^3/min (ft^3/min) (dry)

A_{oi} = Orifice area $\frac{(\text{diam})^2}{4}$, cm^2 ($in.^2$)

$T_{m(avg)}$ = Average meter temperature, °K (°R)

P_m = Absolute meter pressure (see equation above,) mm Hg (in Hg)

M_m = Molecular weight of air, 29.0 g/g-mole (lb_m/lb-mole)

R = Gas law constant, 8.314 joule/g-mole °K (1545 ft-lb_f/lb-mole °R)

ΔH_i = Orifice "i" pressure drop, mm H_2O (in H_2O)

g_c = Gravitational constant, 6.67×10^{-8} $cm^3/g\ sec^2$ (32.17 lb_m-ft/lb_f sec^2)

The orifice constants may be determined without the bell prover by noting the dry gas meter volumes obtained by pumping at 2.5, 5.1, 10.2, and 15.3 cm H_2O (1, 2, 4 and 6 in H_2O) for 3-minute periods. Checking orifice constants in the field and obtaining consistent values for these provides indication of an unchanging calibration during extended field use.

After each series of field tests, the calibration of the metering system must be checked by performing three calibration measurements at a single intermediate orifice setting at or near the average used during the field testing. If the calibration has changed by more than 5%, recalibrate the meter over the full range of orifice settings. Calculations for the test series should then be performed using whichever calibration results in the lower value for total sample volume.

4.4 Probe Heater.

The probe heating system shall be calibrated before each initial use in the field and checked after each series of field tests according to the procedure outlined in Rom (8).

4.5 Thermocouples.

Each thermocouple must be permanently and uniquely marked on the casing; all mercury-in-glass reference thermometers must conform to ASTM E-1 #63C or 63F specifications (9). Thermocouples should be calibrated in the laboratory without the use of extension leads. If extension leads are used in the field, the thermocouple reading at ambient air temperatures, with and without the extension lead, must be noted and recorded. Correction is necessary if the use of an extension lead produces a change greater than 1.5%.

4.5.1 Impinger, Organic Module and Dry Gas Meter Thermocouples. For the thermocouples used to measure the temperature of the gas leaving the impinger train and the XAD-2® resin bed, a three-point calibration at ice water, room air and boiling water temperatures is necessary. Accept the thermocouples only if the readings at all three temperatures agree to ± 2°C (3.6°F) with those of the absolute value of the reference thermometer.

4.5.2 Probe and Stack Thermocouple. For the thermocouples used to indicate the probe and stack temperatures, a three-point calibration at ice water, boiling water and hot oil bath temperatures must be performed; it is recommended that room air temperature be added as a fourth calibration point. If the absolute values of the reference thermometer and the thermocouple agree to within 1.5% at each of the calibration points, a calibration curve (equation) may be constructed (calculated), and the data extrapolated to cover the entire temperature range suggested by the manufacturer.

4.6 Aneroid Barometer.

Adjust the barometer initially and before each test series to agree within ± 2.5 mm Hg (0.1 in. Hg) of the mercury barometer, or the barometric pressure value reported by a nearby National Weather Service station and corrected for elevation.

4.7 Triple-beam Balance.

Calibrate the triple beam balance before each test series using Class-S standard weights; the weights must be within ± 0.5% of the standards, or the balance adjusted to meet these limits.

5. Calculations

Carry out the calculations, insuring that the final number of significant figures are preserved after the final calculation. Other forms of the equations may be used provided the results are equivalent.

5.1 Nomenclature

A_n = Cross sectional area of nozzle, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream, proportion by volume.

C_d = Type S pitot tube coefficient (nominally 0.84 ± 0.02), dimensionless.

C_{mm} = Methanol/methylene chloride unit blank correction, mg/g of solvent.

C_p = Concentration of particulate material in the stack gas (gr/dscf).

I = Percent of ioskinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.0014 m^3/min (0.05 cfm) or 4 percent of the average sampling rate.

L_i = Individual leakage rate observed during the leak check conducted prior to the "i"th component change ($i=1, 2, 3 \ldots n$) m^3/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m^3/min (cfm).

M_d = Stack gas dry molecular weight, g/g-mole (lb/lb-mole).

M_m = Weight of methanol/methylene chloride residue after evaporation, mg.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_{bar} = Barometric pressure at the sampling site, mm. Hg (in. Hg).

P_s = Absolute stack gas pressure, mm. Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm. Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 mm. Hg-m^3/°K-g-mole (21.85 in. Hg-ft^3/°R-lb-mole)

T_m = Absolute average dry gas meter temperature, °K(°R).

T_s = Absolute average stack gas temperature, °K(°R).

T_{std} = Standard absolute temperature, 293°K (528°R).

V_{lc} = Total volume of liquid collected in the organic module condensate knockout trap, the impingers and silica gel, mL.

V_m = Volume of gas sample as measured by dry gas meter, dcm(dscf).

V_{mm} = Volume of methanol/methylene chloride used for front-half wash, mL.

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).

v_s = Stack gas velocity, calculated by EPA Method 2 (3), Equation 2-9, using data obtained from particulate field data, m/sec (ft/sec).

W_{mm} = Weight of residue in methanol/methylene chloride wash, mg.

W_{pf-a}, W_{pf-b}, W_{pf-c}m... = Particulate weight catch from filter Pf-a, Pf-b, Pf-c, etc. used during the run, mg.

W_{10c}, W_{3c}, W_{1c} = Particulate weight catch from the 10 um, 3 um and 1 um cyclones, respectively, mg.

W_p = Total weight of particulate material collected during run, mg.

W_{pr} = Weight of front-half rinse residue before blank correction, mg.

Y = Dry gas meter calibration factor, dimensionless

ΔH = Average pressure differential across the orifice meter, mm. H_2O (in. H_2O).

ρ_{mm} = Density of a 50:50 (v/v) mixture of methanol/methylene chloride, g/mL (lb/mL); see labels on bottles.

ρ_w = Density of water, 0.9982 g/mL (0.002201 lb/mL) at 2°C (68°F).

θ = Total sampling time, min.

θ_{i-1} = Sampling time interval between two successive component changes beginning with the interval between the first and second changes, min.

θ_p = Sampling time interval from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

5.2 Dry Gas Volume

1. From the SASS run sheet, average the dry gas meter temperatures and orifice pressure drop readings throughout the run.

2. Calculate the Dry Gas Volume at standard conditions: (20°C, 760 mm Hg; 528°R, 29.92 in. Hg) using the equation:

$$V_{m(std)} = V_m \left[\frac{T_{std}}{T_m}\right] \left[\frac{P_{bar} + (\Delta H/13.6)}{P_{std}}\right]$$

$$= K_1 V_m \left[\frac{P_{bar} + (\Delta H/13.6)}{T_m}\right]$$

where: K_1 = 0.358 °K/mm. Hg for metric units
= 17.64 °R/in. Hg for English Units

The above equation must be modified whenever the leakage rate observed during the post-test leak-check or any leak-check made prior to a component change exceeds the maximum allowed. The modification follows:

(a) Case I. No component changes have been made during the sampling run, and the allowable leakage rate has been exceeded during the post-test leak check.

Replace V_m with the expression:

$$\left[V_m - \theta_p(L_p - L_a)\right]$$

(b) Case II. One or more component changes made during the sampling run, and the allowable leakage rate has been exceeded during one or more of the leak checks prior to component changes or during the post-test leak check.

Replace V_m with the expression

$$V_m - \sum_{i=1}^{n}\left[\theta_{i-1}(L_i - L_a) - \theta_p(L_p - L_a)\right]$$

5.3 Moisture Content

5.3.1 Volume of Water Vapor at Standard Conditions.

Calculate according to:

$$V_{w(std)} = V_{1c}\left[\frac{P_w}{M_w}\right]\left[\frac{RT_{std}}{P_{std}}\right] = K_2 V_{1c}$$

where: K_2 = 0.001333 m^3/mL for metric units

= 0.04707 ft^3/g for English units

5.3.2 Percent Moisture.

Calculate using the equation:

$$\%M = 100 \times B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}} \times 100$$

Note: In saturated or water droplet-laden gas streams, make two calculations of the moisture content, one from the total volume of liquid collected in the train and one from the assumption of saturated gas streams conditions. Use whichever method results in the lower value. To determine the moisture content based upon saturated conditions, use the average stack gas temperature in conjunction with saturation vapor pressure tables (10).

5.4 Particulate Concentration.

5.4.1 Unit Blank Weight Correction. Calculate for all front-half samples, as follows:

$$C_{mm} = \frac{M_{mm}}{V_{mm} \rho_{mm}}$$

5.4.2 Blank Weight Correction for Each Sample. Calculate for each individual front-half sample as follows:

$$W_{mm} = C_{mm} V_{mm} \rho_{mm}$$

5.4.3 Blank-corrected Total Particulate Weight. Calculate according to:

$$W_p = (W_{pf-a} + W_{pf-b} + \ldots\ldots) + (W_{10c} + W_{3c} + W_{1c}) + (W_{pr} - W_{mm})$$

5.4.4 Particulate Concentration. Calculate according to:

$$C_p = (0.001 \text{ g/mg})\ (W_p / V_{m(std)})$$

5.4.5 Conversion Factors. To convert the above concentration to units of gr/ft^3 or lb/ft for comparison with estabilished or projected values, the following conversion factors are useful

From	To	Multiply by
scf	m^3	0.02832
g/ft^3	gr/ft^3	15.43
g/ft^3	lb/ft^3	2.205×10^{-3}
g/ft^3	g/m^3	35.315
g/m^3	gr/ft^3	0.4370

5.5 Isokinetic Variation.

5.5.1 Calculation from Unreduced Data.

$$I = \frac{100\ T_s\ K_3 V_{1c} + \ (V_m/T_m)\ (P_{bar} + \Delta H/13.6)}{60\ v_s P_s A_n}$$

where:

K_3 = 0.003454 mm. Hg-m³/mL-°K for metric units
= 0.002669 in. Hg-ft³/mL-°R for English units

5.5.2 Calculation from Intermediate Values.

$$I = \frac{T_s V_{m(std)} P_{std} 100}{T_{std} V_s \theta A_n P_s 60(1-B_{ws})}$$

$$= K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1-B_{ws})}$$

where: K_4 = 4.320 for metric units
= 0.09450 for English units

5.5.3 Acceptable Results. If $70\% < I < 150\%$, the results are acceptable.

5.6 Cyclone Particle Size Cutoff Diameter.

The range of particle sizes collected in each cyclone and on the filter is dependant upon the operating temperature and flowrate during sampling. The particle size cutoff diameters of 10, 3, and 1 um in the cyclones have been established at 204°C (400°F) and 0.11 scmm (4.0 scfm). When actual sampling conditions deviate substantially (25% for each) from these, the above particle size cutoff diameters should be restabilished. To estimate the new particle size cutoff diameters, it is necessary only to extrapolate from those at 204°C (400°F) and 0.11 scmm (4.0 scfm) assuming that a square and an inverse square root dependence exists upon temperature and flowrate, respectively. This extrapolation is, however, only an estimate; existing calibration data are insufficient to determine exact mathematical relationships for the variation of particle size cutoff diameters with temperature and flowrate*.

---

*Source: Private Communication with J.D. McCain of Southern Research Institute, 2000 Ninth Ave. Birmingham, AL 35205

5.6.1 Cumulative Particulate Weight Percent less than Calculated Size.

1. Divide the weight collected in the individual cyclones and on the filter by the total weight of particulate collected. Express these as a percentage, using the following equations:

$$\% W_{pf} = \frac{W_{pf-a} + W_{pf-b} + \ldots.}{W} \times 100$$

$$\% W_{10c} = \frac{W_{10c}}{W_p} \times 100$$

$$\% W_{3c} = \frac{W_{3c}}{W_p} \times 100$$

$$\% W_{1c} = \frac{W_{1c}}{W_p} \times 100$$

2. Cumulative Weight Percent less than the Calculated Particle Size Cut-off Diameter. For each fraction, calculate by adding the weight percent of all fractions having a smaller particle size cut-off diameter than the stated size. Tabulate the data, using the form below as an example:

TABLE 6. PRESENTATION OF SASS PARTICLE SIZING DATA

Stage	Weight % Collected in Stage	Cumulative Weight % Less than Calculated Particle Size Cut off Diameter	Calculated Particle Size Cut Off Diameter (um)
10 um cyclone	12%	88%	10.3 um
3 um cyclone	12	76	2.9
1 um cyclone	48	48	1.1
Glass or Quartz Fiber Filter	28	0	-

6. References.

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4. Blake, D.F. Source Assessment Sampling System: Design and Development. EPA 600/7-78-018 PB-279 757/9BE, U. S. Environmental Protection Agency, Research Triangle Park, N.C., February 1978. 207 pp.

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8. Rom, J.J. Maintenance, Calibration and Operation of Isokinetic Source Sampling Equipment. PB-209 022/BE, APTD-0576, U. S. Environmental Protection Agency, Research Triangle Park, N.C., March 1972. 39 pp.

9. E.H.S.L. Quality Assurance Handbook for Air Pollution Measurement Systems. Vol. III, Stationary Source Specific Methods. EPA-600/4-77-027b, U. S. Environmental Protection Agency, Research Triangle Park, N.C., August 1977.

10. Western Precipitation Corp. Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases. Bulletin WP-50, Western Precipitation Corp., Los Angeles, CA.

APPENDIX A

MM5 BLANK DATA FORMS

VELOCITY/TEMP PROFILE DATA

PLANT____________________
DATE____________________
RUN NO.____________________
STACK DIAMETER, in.________________
BAROMETRIC PRESSURE, in. Hg.____________
STATIC PRESSURE IN STACK (P_g), in. Hg.________
OPERATORS____________________

SCHEMATIC OF STACK CROSS SECTION

Traverse point number	Velocity head, in. H_2O	SP ("H_2O)	CFA (°)	Stack Temperature (T_S), °F
	AVERAGE:			

Traverse point number	Velocity head, in. H_2O	SP (" H_2O)	CFA (°)	Stack Temperature (T_S), °F
	AVERAGE:			

SP = Static Pressure
CFA = Cyclonic Flow Angle

DRY GAS METER/ORIFICE METER CALIBRATION FORM

Date ________________________ Box No. ________________

Barometric pressure, P_b = ___in. Hg Dry gas meter No. ________________

Orifice manometer setting, ΔH, in. H_2O	Gas volume wet test meter V_w, ft^3	Gas volume dry gas meter V_d, ft^3	Temperature				Time θ, min	γ	ΔH@
			Wet test	Dry gas meter					
			Meter t_w, °F	Inlet t_{di}, °F	Outlet t_{do}, °F	Average t_d, °F			
0.5	5								
1.0	5								
1.5	10								
2.0	10								
3.0	10								
4.0	10								
6.0	10								
							Average		

Calculations

ΔH	$\frac{\Delta H}{13.6}$	γ	ΔH@
		$\frac{V_w P_b (t_d + 460)}{V_d\left(P_b + \frac{\Delta H}{13.6}\right)\left(t_w + 460\right)}$	$\frac{0.0317\ \Delta H}{P_b\ (t_d + 460)}\left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
1.5	0.1103		
2.0	0.147		
3.0	0.221		
4.0	0.294		
6.0	0.431		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01

ΔH@ = Orifice pressure differential that gives 0.75 cfm of air at 70° F and 29.92 inches of mercury, in. H_2O. Tolerance - ± 0.15

PARTICULATE FIELD DATA

PLANT ____________
LOCATION ____________
OPERATOR ____________
DATE ____________
RUN NO. ____________
SAMPLE BOX NO. ____________
METER BOX NO. ____________
METER ΔH@ ____________
C FACTOR ____________
PITOT TUBE COEFFICIENT, Cp ____________

SCHEMATIC OF STACK CROSS SECTION

BAROMETRIC PRESSURE ____________
ASSUMED MOISTURE, % ____________
PROBE EXTENSION LENGTH, m(ft.) ____________
NOZZLE IDENTIFICATION NO. ____________
AVERAGE CALIBRATED NOZZLE DIAMETER cm (in.) ____________
FILTER NO. ____________
LEAK RATE, m^3/min, (cfm) ____________
STATIC PRESSURE, mm Hg (in. Hg) ____________

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	VACUUM mm Hg (in. Hg)	STACK TEMPERATURE (T_S), °C (°F)	VELOCITY HEAD (ΔP_S), mm H_2O (in. H_2O)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER, mm H_2O (in. H_2O)	GAS SAMPLE VOLUME, m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
							INLET, °C (°F)	OUTLET, °C (°F)	
TOTAL							Avg	Avg	
AVERAGE							Avg		

ORSAT Analysis Data Sheet

PLANT ______________________ COMMENTS: __________

SAMPLE LOCATION ______________________ __________

DATE ______________________ __________

RUN ______________________ __________

OPERATOR ______________________ __________

W. O. NO. ______________________ __________

SAMPLE POINT	TIME	(CO_2) READING 1	(O_2) READING 2		(CO) READING 3	
			ACTUAL	NET	ACTUAL	NET

Net O_2 reading = Reading 2 - Reading 1 (Actual)

Net CO reading = Reading 3 - Reading 2 (Actual)

PARTICULATE RECOVERY SHEET

Plant____________________ Sample No.__________

Sampling Location____________________ Run No.__________

Recovered By__________ Recovery Date__________ Run Date__________

Comments____________________

Analyst Responsible____________________

Calculations and Report Reviewed by__________ Report Date__________

FILTERS USED

No.__________

____

____

____

____

CYCLONES

	Used (yes/no)	Pretared Container (No.)
10u		
3μ		
1μ		

IMPINGER VOLUMES	Initial	Final	
First	mL	mL	
Second	mL	mL	
Third	mL	mL	
Totals	mL	mL	Gain__________mL

SILICA GEL WEIGHTS

	Initial	Final	
	g	g	
	g	g	
	g	g	
TOTALS	g	g	Gain__________g

CONDENSATE

TOTAL VOLUME COLLECTED __________mL

Volume Neat __________mL

Volume Extracted __________mL

Volume CH_2Cl_2 Extract (3 x _____mL)__________mL

Extracted Condensate: pH Neat __________

Amount (drops) HNO_3 added __________

Amount (drops) NaOH added __________

Total Gain__________mL

SAMPLE PACKING SHEET

Sample Site ____________________
Date Sampled ____________________
Shipped By ____________________
Date Shipped ____________________
Carrier ____________________

ID Number ____________ Test Number ____________
Invoice Number ____________________
Date Received ____________________
Received By ____________________
Condition ____________________

Sample No.	Collected (yes/no)	Date Recovered/Prep	Time	Weight (g) or Volume (mℓ)	Field Adjustments/Observations

Signature ____________________

Page ____ of ____

CHAIN OF CUSTODY RECORD

Shipper's Name

Case Number________

Collector's Name(s) ____________________ ____________________

Location of Sampling
Facility Name
Address
____
____
____
____

Process Description
____
____
____
____

Sample Numbers	Date & Time	Sample Numbers	Date & Time

Samples Shipped by (Carrier)____________________________________
____

Samples Shipped to

Chain of Possession

Name	Title	Dates

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date ____________________________ Thermocouple number ___________

Ambient temperature _______°C Barometric pressure _______ in. Hg

Calibrator __________ Reference: mercury-in-glass ______________

other ________________________

Reference point number	Source (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, %

APPENDIX B

PREPARATION OF XAD-2 SORBENT RESIN

B.1 SCOPE AND APPLICATION

XAD-2 resin, as supplied by the manufacturer, is impregnated with a bicarbonate solution to inhibit microbial growth during storage. Both the salt solution and any residual extractable monomer and polymer species must be removed before use. The resin is prepared by a series of water and organic extractions followed by careful drying.

B.2 EXTRACTION

B.2.1 Method 1

The procedure may be carried out in a giant Soxhlet extractor, which will contain enough XAD-2 for a single SASS module. An all-glass thimble (55-90 mm OD x 250 mm deep [top to frit]) containing an extra-coarse frit is used for extraction of XAD-2. The frit is recessed 10-15 mm above a crenulated ring at the bottom of the thimble to facilitate drainage. The resin must be carefully retained in the extractor cup with a glass wool plug and stainless steel screen since it floats on the final solvent, methylene chloride. This process involves sequential extraction in the following order.

Solvent	Procedure
Water	Initial rinse with 1 L H_2O for 1 cycle, then discard H_2O
Water	Extract with H_2O for 8 hours
Methyl alcohol	Extract for 22 hours
Methylene chloride	Extract for 22 hours
Methylene chloride (fresh)	Extract for 22 hours

B.2.2 Method 2

As an alternate to Soxhlet extraction, a continuous extractor has also been fabricated for the extraction sequence and is described in Figure B-1. This extractor has been found to be acceptable. The particular canister used for the apparatus shown in Figure B-1 contains about 500 g of finished XAD-2 or enough for more than three sorbent modules. Any size may be constructed; the choice is dependent on the needs of the sampling programs. The XAD-2 is held under light spring tension between a pair of coarse and fine screens. Spacers under the bottom screen allow for even distribution of clean solvent. The three-necked flask should be of sufficient size (3 L in this case) to hold solvent equal to twice the dead volume of the XAD-2 canister. Solvent is refluxed through the Snyder column and the distillate continuously cycled up through the XAD-2 for extraction and returned to the flask. The flow is maintained upwards through the XAD-2 to allow maximum solvent contact and prevent channeling. A valve at the bottom of the canister allows removal of solvent from the canister between changes.

Experience has shown that it is very difficult to cycle sufficient water in this mode. Therefore, the aqueous rinse is accomplished by simply flushing the canister with about 20 L of distilled water. A small pump may be useful for pumping the water through the canister. The water extraction should be carried out at the rate of about 20-40 mL/min.

After draining the water, subsequent methyl alcohol and methylene chloride extractions are carried out using the refluxing apparatus. An overnight or 10- to 20-hour period is normally sufficient for each extraction.

All materials of construction are glass, Teflon, or stainless steel. Pumps, if used, should not contain extractable materials. Pumps are not used with methanol and methylene chloride.

B.3 DRYING

After evaluation of several methods of removing residual solvent, a fluidized-bed technique has proven to be the fastest and most reliable drying method.

A simple column with suitable retainers as shown in Figure B-2 will serve as a satisfactory column. A 10.2-cm (4-in.) Pyrex pipe 0.6 m (2 ft)

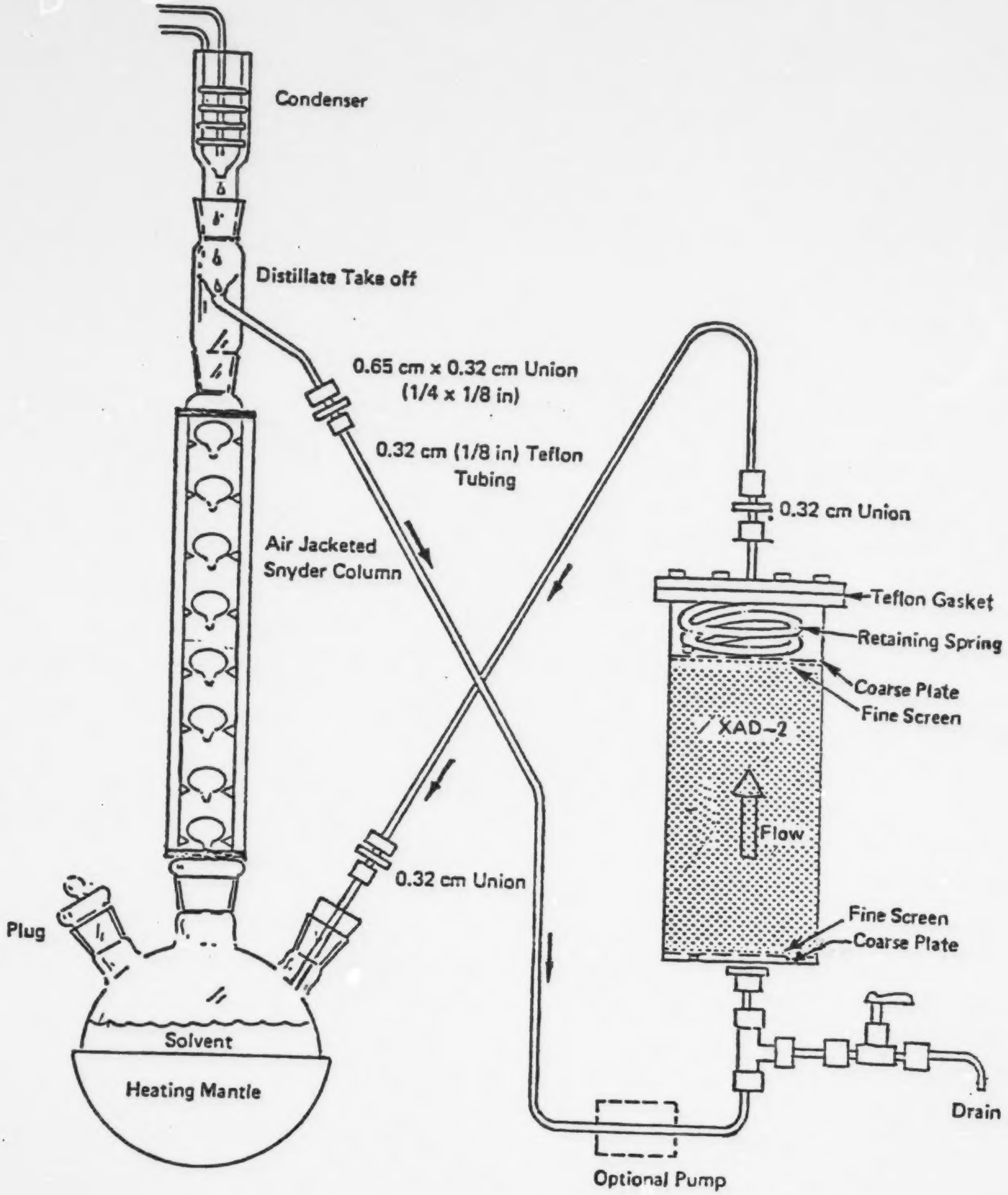
Condenser
Distillate Take off
0.65 cm x 0.32 cm Union
(1/4 x 1/8 in)
0.32 cm (1/8 in) Teflon
Tubing
Air Jacketed
Snyder Column
0.32 cm Union
Teflon Gasket
Retaining Spring
Coarse Plate
Fine Screen
XAD-2
Flow
0.32 cm Union
Plug
Fine Screen
Coarse Plate
Solvent
Heating Mantle
Drain
Optional Pump

Figure B-1. XAD-2 cleanup extraction apparatus.

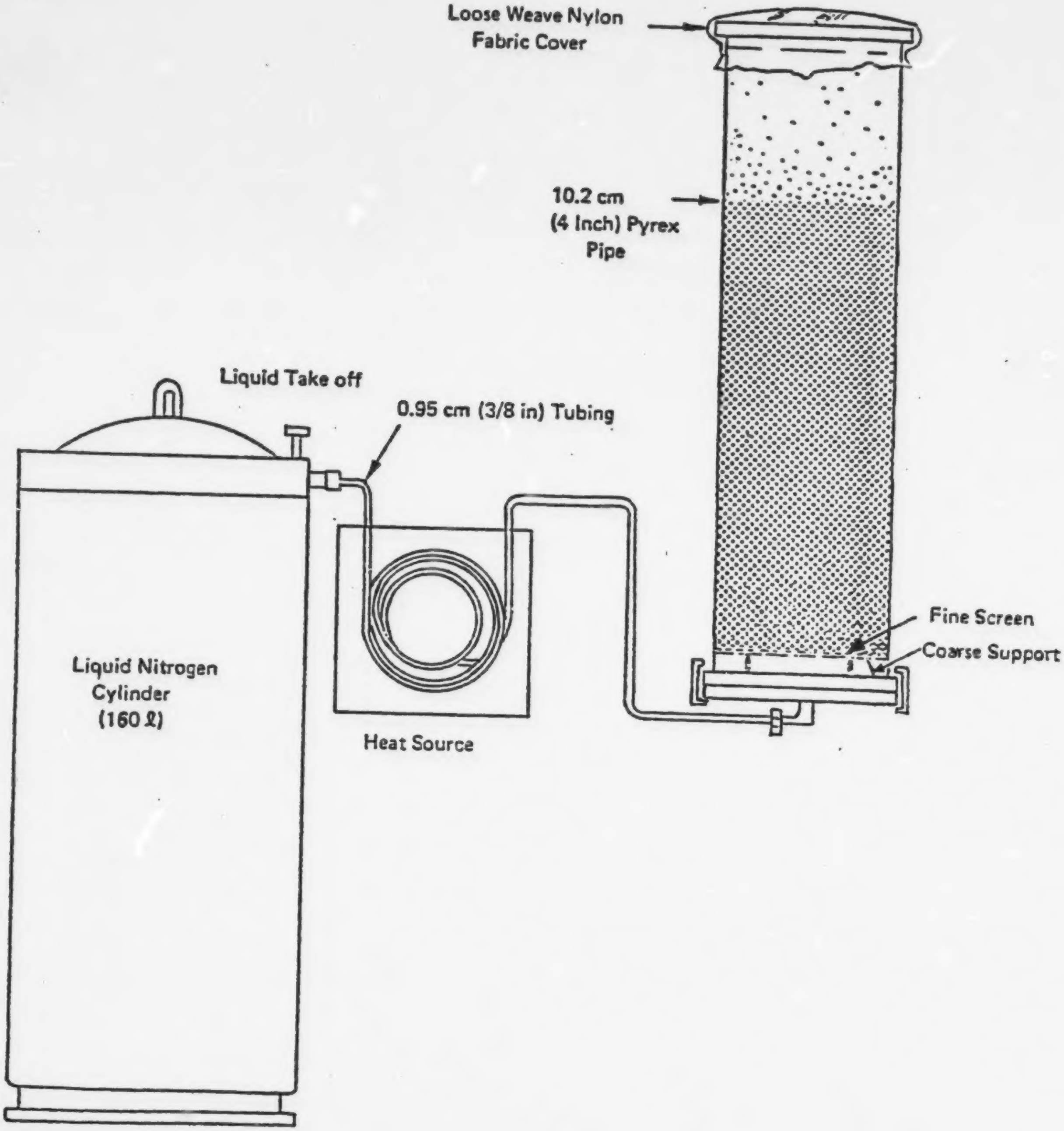
Loose Weave Nylon
Fabric Cover
10.2 cm
(4 Inch) Pyrex
Pipe
Liquid Take off
0.95 cm (3/8 in) Tubing
Fine Screen
Coarse Support
Liquid Nitrogen
Cylinder
(160 ℓ)
Heat Source

Figure B-2. XAD-2 fluidized-bed drying apparatus.

long will hold all of the XAD-2 from the extractor shown in Figure B-1 or the Soxhlet extractor, with sufficient space for fluidizing the bed while generating a minimum resin load at the exit of the column.

B.3.1 Method 1

The gas used to remove the solvent is the key to preserving the cleanliness of the XAD-2. Liquid nitrogen from a regular commercial liquid nitrogen cylinder has routinely proven to be a reliable source of large volumes of gas free from organic contaminants. The liquid nitrogen cylinder is connected to the column by a length of precleaned 0.95-cm (3/8-in.) copper tubing, coiled to pass through a heat source. As nitrogen is bled from the cylinder, it is vaporized in the heat source and passes through the column. A convenient heat source is a water bath heated from a steam line. The final nitrogen temperature should only be warm to the touch and not over 40° C. Experience has shown that about 500 g of XAD-2 may be dried overnight consuming a full 160-L cylinder of liquid nitrogen.

B.3.2 Method 2

As a second choice, high purity tank nitrogen may be used to dry the XAD-2. The high purity nitrogen must first be passed through a bed of activated charcoal approximately 150 mL in volume. With either type of drying method, the rate of flow should gently agitate the bed. Excessive fluidization may cause the particles to break up.

B.4 QUALITY CONTROL PROCEDURES

For both Methods 1 and 2, the quality control results must be reported for the batch. The batch must be reextracted with methylene chloride if the residual extractable organics are greater than 20 µg/mL or the gravimetric residue is greater than 0.5 mg/20 g XAD-2 extracted.

Three control procedures are used with the final XAD-2 to check for (1) residual methylene chloride, (2) extractable organics (TCO), and (3) residue (GRAV).

B.4.1 Procedure for Residual Methylene Chloride

B.4.1.1 Description--

A 1 ±0.1 g sample of dried resin is weighed into a small vial, 3 mL of toluene are added, and the vial is capped and well shaken. Five microliters of toluene (now containing extracted methylene chloride) are injected into a gas chromatograph, and the resulting integrated area is compared to a reference standard.

The reference solution consists of 2.5 μL of methylene chloride in 100 mL of toluene, simulating 100 μg residual methylene chloride on the resin. The acceptable maximum content is 1,000 μg/g resin.

B.4.1.2 Experimental--

- 6 ft. x 1/8 in. SS column containing 10% OV-101 on 100/120 Supelcoport
- Helium carrier at 30 mL/min
- FID operated on 4 x 10^{-11} A/mV
- Injection port temp 250° C, detector temp 305° C
- Programmed: 30° C (4 min) $\underline{40°/\text{min}}$ 250° C (hold)
  Program terminated at 1000 seconds.

B.4.2 Procedure for Residual Extractable Organics

B.4.2.1 Description--

A 20 ±0.1 g sample of cleaned, dried resin is weighed into a precleaned alundum or cellulose thimble which is plugged with cleaned, glass wool. (Note that 20 g of resin will fill a thimble, and the resin will float out unless well plugged.) The thimble containing the resin is extracted for 24 h with 200 mL of pesticide-grade methylene chloride.*

The 200-mL extract is reduced in volume to 10 mL using a nitrogen evaporation stream. Five microliters of that solution are analyzed by gas chromatography using the TCO analysis procedure. The concentrated solution should not contain more than 20 μg/mL of TCO extracted from the XAD-2. This is equivalent to 10 μg/g of TCO in the XAD-2 and would correspond to 1.3 mg of TCO in the extract of the 130-g XAD-2 module. Care should be taken to correct the TCO data for a solvent blank prepared (200 → 10 mL concentration) in a similar manner.

B.4.2.2 Experimental--

Use the TCO analysis conditions described in the revised Level 1 manual.

---

*Burdick & Jackson pesticide grade or equivalent purity.

B.4.3 Methodology for Residual Gravimetric Determination.

After the TCO value is obtained for the resin batch by the above procedures, dry the remainder of the extract in a tared vessel. There must be less than 0.5 mg residue registered or the batch of resin will have to be extracted with fresh methylene chloride again until it meets this criteria. This level corresponds to 25 µg/g in the XAD-2 or about 3.25 mg in a resin charge of 130 g.

APPENDIX C

SASS BLANK DATA FORMS

VELOCITY/TEMP PROFILE DATA

PLANT ____________________

DATE ____________________

RUN NO. ____________________

STACK DIAMETER, in. ____________________

BAROMETRIC PRESSURE, in. Hg. ____________________

STATIC PRESSURE IN STACK (P_g), in. Hg. __________

OPERATORS ____________________

SCHEMATIC OF STACK CROSS SECTION

Traverse point number	Velocity head, in. H_2O	SP ("H_2O)	CFA (°)	Stack Temperature (T_S), °F
	AVERAGE:			

Traverse point number	Velocity head, in. H_2O	SP (" H_2O)	CFA (°)	Stack Temperature (T_S), °F
	AVERAGE:			

SP = Static Pressure
CFA = Cyclonic Flow Angle

SASS FIELD DATA

Plant ______
Date ______
Sampling Location ______
Source I.D. ______
Run Number ______
Operator ______
Ambient Temperature ______
Barometric Pressure ______
Static Pressure, (P_s) ______
Filter Number(s) ______
______

Probe Length and Type ______
Nozzle, I.D. ______
Assumed Moisture, % ______
XAD-2 Module Number ______
Meter Box Number ______ Oven Number ______
Meter ΔH. ______
C Factor ______
Probe Heater Setting ______
Oven Setting ______
Reference ΔP ______
Calculations and Report Checked By ______ Report Date ______

SCHEMATIC OF TRAVERSE POINT LAYOUT
READ AND RECORD ALL DATA EVERY ___ MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 HR CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (ΔP_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_S), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM in Hg	OVEN TEMPERATURE °F	IMPINGER TEMPERATURE °F	SORBENT TRAP TEMPERATURE °F	PROBE TEMPERATURE °F
					DESIRED	ACTUAL		INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F					
TOTAL		●		●	●	●	●	●	●	●	●	●	●	●
AVERAGE	●	●	●	●	●					●	●	●	●	●

COMMENTS

RC1/ORSAT COLLECTION DATA SHEET

Facility____________________ Sampling Location____________

Date________________________ Operator____________________

Run#________________________

RC1

Sample ID	Run Time		Pump Calibration		Pump No.
	Start	Stop	Before	After	

ORSAT

Sample ID	Run Time		Nominal Pump Flow Rate	Approximate Volume Collected
	Start	Stop		

ORSAT Analysis Data Sheet

PLANT ______________________

SAMPLE LOCATION ______________________

DATE ______________________

RUN ______________________

OPERATOR ______________________

W. O. NO. ______________________

COMMENTS: ______________________

____

____

____

____

____

SAMPLE POINT	TIME	(CO_2) READING 1	(O_2) READING 2		(CO) READING 3	
			ACTUAL	NET	ACTUAL	NET

Net O_2 reading = Reading 2 - Reading 1 (Actual)

Net CO reading = Reading 3 - Reading 2 (Actual)

FIXED GASES

1. Column Flow Rate (mL/min) ______ 2. Recorder Speed ______

3. Full Scale (mV) ______ 4. Column Pressure (psi) ______

5. Electrometer Set (A/mV) ______ 6. Calibration Date ______

7. Sample Size (mL) ______ 8. Oven Temperature (°C) ______

9. Attenuation ______ 10. Range ______

11. Observations ______

12. Analyst Responsible ______ Date Analyzed ______ Time ______

13. Calculations and Report Reviewed By ______ Report Date ______

Gas	Uncorrected Sum of Peak Areas	Blank Value	Retention Time	Corrected Sum of Peak Areas	Conc. (%)	Sensitivity	High/Low Calibration Standards	Conc. (ppm)
O_2								
CO_2								
CO								
N_2								

Results: PPM value (in original sample) or I - interference; NC - not computed; NB - sample value below blank; ND - not detectable (<2 σ blank or baseline).

PARTICULATE RECOVERY SHEET

Plant ____________________ Sample No. __________

Sampling Location ____________________ Run No. __________

Recovered By __________ Recovery Date __________ Run Date __________

Comments ______________________________

Analyst Responsible ______________________________

Calculations and Report Reviewed by __________ Report Date __________

FILTERS USED		CYCLONES	
		Used (yes/no)	Prepared Container (No.)
No. ________	10µ	________	________
________	3µ	________	________
________	1µ	________	________
________			
________			

IMPINGER VOLUMES	Initial	Final	
First	________ mL	________ mL	
Second	________ mL	________ mL	
Third	________ mL	________ mL	
Totals	________ mL	________ mL	Gain ________ mL

SILICA GEL WEIGHTS

	Initial	Final	
	________ g	________ g	
	________ g	________ g	
	________ g	________ g	
TOTALS	________ g	________ g	Gain ________ g

CONDENSATE

TOTAL VOLUME COLLECTED ________ mL

Volume Neat ________ mL

Volume Extracted ________ mL

Volume CH_2Cl_2 Extract (3 x ____ mL) ________ mL

Extracted Condensate: pH Neat ________

Amount (drops) HNO_3 added ________

Amount (drops) NaOH added ________

Total Gain ________ mL

SAMPLE PACKING SHEET

Sample Site ______________________
Date Sampled ______________________
Shipped By ______________________
Date Shipped ______________________
Carrier ______________________

ID Number ______________ Test Number ______________
Invoice Number ______________________
Date Received ______________________
Received By ______________________
Condition ______________________

Sample No.	Collected (yes/no)	Date Recovered/Prep	Time	Weight (g) or Volume (mℓ)	Field Adjustments/Observations

Signature ______________________

Page ____ of ____

CHAIN OF CUSTODY RECORD

Shipper's Name

Case Number________

Collector's Name(s) ____________________ ____________________

Location of Sampling
Facility Name
Address
____
____
____
____

Process Description
____
____
____
____

Sample Numbers	Date & Time	Sample Numbers	Date & Time

Samples Shipped by (Carrier)____
____

Samples Shipped to

Chain of Possession

Name	Title	Dates

DRY GAS METER (DGM) CALIBRATION FORM

DGM#______________ Person/Date____________________

Time (min)	Δ H (in H_2O)	Gasometer Temp initial (°F)	Gasometer Pressure average (in H_2O)	Gasometeter Height Final (cm)	Gasometer Height Initial (cm)	DGM Volume Final (ft^3)	DGM Volume Initial (ft^3)	DGM Inlet Temp final (°F)	DGM Inlet Temp initial (°F)	DGM Outlet Temp final (°F)	DGM Outlet Temp initial (°F)	DGM Pressure average (in Hg)	
5	0.5												Barometric Pressure (in Hg)
	0.5												
	1.0												final________
	1.0												initial________
3	2.0												
	2.0												Leak Check
	4.0												________ft^3
	4.0												@________in Hg
2	6.0												
	6.0												
	8.0												
	8.0												

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date ____________________ Thermocouple number __________

Ambient temperature ______°C Barometric pressure ______ in. Hg

Calibrator ________ Reference: mercury-in-glass ____________

other ____________________

Reference point number	Source (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, %

APPENDIX D

Contract 68-02-2685
Work Assignment 112

Design and Fabricate a Corrosion Resistant Organic Sorbent Module

Draft Final Report, Work Assignment 112

Susan Berg, Principal Investigator
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D. Bruce Harris, Task Officer
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Technical Support Staff (MD-62)
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

May 10, 1982
Project 4097-12-FR
SoRI-EAS-82-401

ACKNOWLEDGEMENTS

The assistance of Wade Mason of PEDCo - Environmental Co. is gratefully acknowledged. Mason freely supplied design advice and answered frequent questions during the course of this project. David Hussey, now of Digital Equipment Co., was the initial principal investigator on this project.

INTRODUCTION

With the currently increasing use of incineration as a means to dispose of hazardous wastes, sampling of incinerator effluent streams has become an important research need. However, attempts to use standard Level I analysis techniques to sample hazardous waste incinerators are complicated by the corrosive nature of incinerator exhaust gases. When chlorinated species are burned, hydrogen chloride vapor is evolved. Experience has shown that the organic module of the Source Assessment Sampling System (SASS)[1] is particularly vulnerable to corrosive attack by these acid vapors.[2] This report describes the design, construction and operation of a sorbent module made of borosilicate glass which may be used as a replacement for the original stainless steel SASS module when corrosive streams are encountered.

DESIGN AND CONSTRUCTION OF THE CORROSION RESISTANT SASS ORGANIC MODULE

BACKGROUND

The potential need for a module that was more chemically inert than the conventional 316 stainless steel device has been recognized in the past, and some conceptual studies have been performed for various alternative designs, including some of glass.[3] Acurex[3] recommended a glass module with a thin-film condenser design which was very similar to that used in the existing stainless steel organic module. This design would almost certainly be functionally identical to the current unit. The major limitations of the Acurex design is its complexity. The device would be difficult to fabricate and more fragile as compared to other possible all-glass designs.

A second concept of glass sorbent module was designed and actually fabricated by PEDCo Environmental Consultants. The PEDCo design uses a coil-type condenser rather than a thin film design. The coil-type condenser is easier to fabricate and less fragile than the thin-film model, but should have less cooling efficiency and be harder to clean. The PEDCo design was dictated by cost considerations rather than the specific need for corrosion resistance, but is satisfactory for the latter purpose as well.

When Southern Research Institute was directed to construct a corrosion-resistant SASS organic module, several design options were considered. The decision was made to adapt the PEDCo design since it had been used in the field and was reported to be simple to assemble, relatively trouble free, and functionally equivalent to the SASS module.

DESIGN DETAILS

Figures 1-7 contain design drawings of the glass organic module. Figure 1 is an assembly drawing of the module. The three major sections of the apparatus shown in Figure 1 are a condenser, a sorbent cartridge, and a collector for condensed moisture. In operation, the gas flow from the oven first passes through the coiled-tube condenser, Figure 2, where it is cooled to 20°C as required for SASS operation. The temperature of the cooling water is adjusted to provide the required outlet temperature as measured by a Teflon-coated thermistor sensor (Love Controls No. 1610-10-100) mounted in the organic sorbent assembly, shown in Figure 3. The thermistor sensor is held in the sorbent cartridge cap by a threaded o-ring compression adaptor, shown in exploded view in Figure 4. The cartridge body (Figure 5) has a well for XAD-2 resin sorbent bounded by a fritted glass plate installed in the bottom of the cartridge and a second glass frit which is removable for loading and unloading of sorbent. The depth of the sorbent bed is about

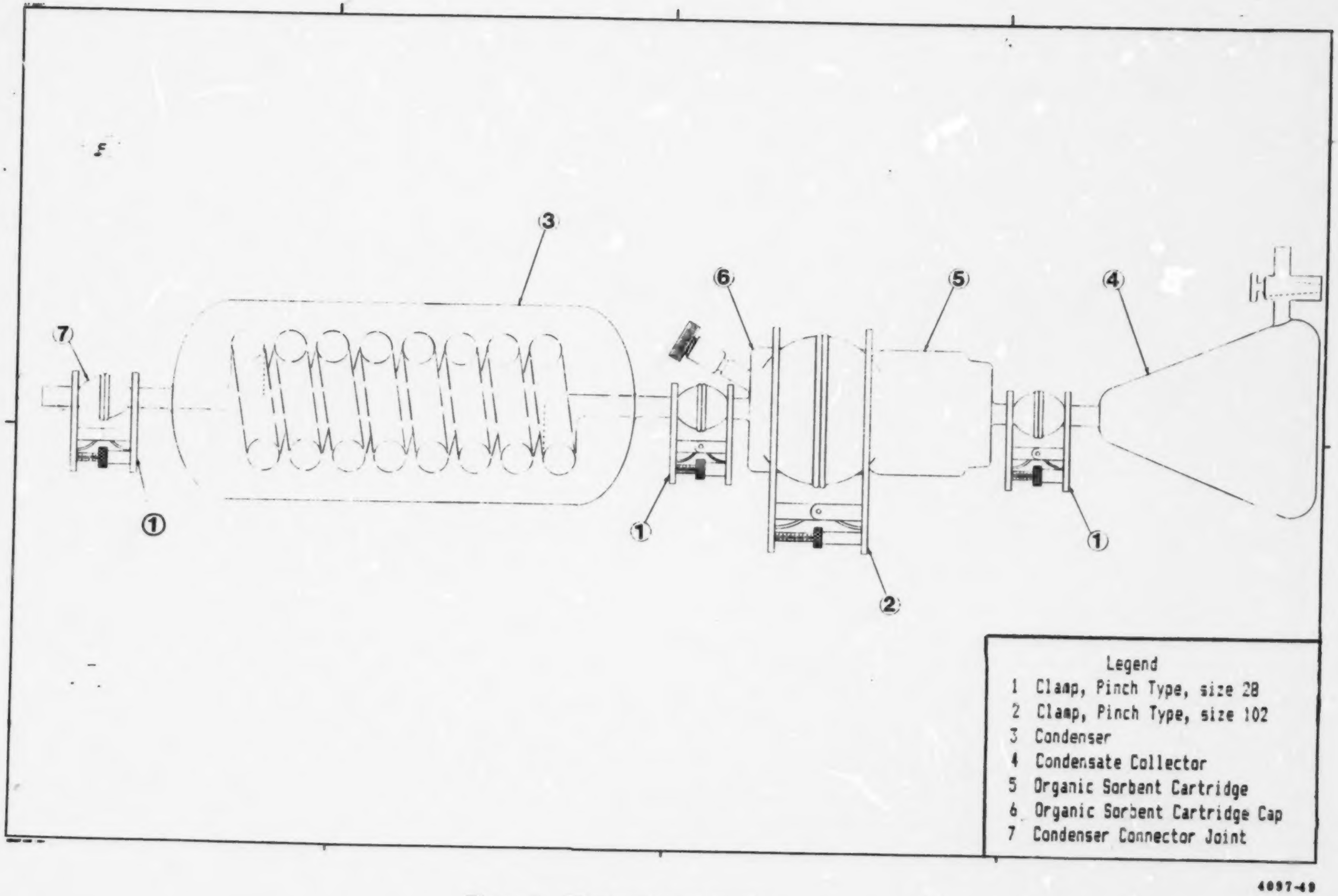
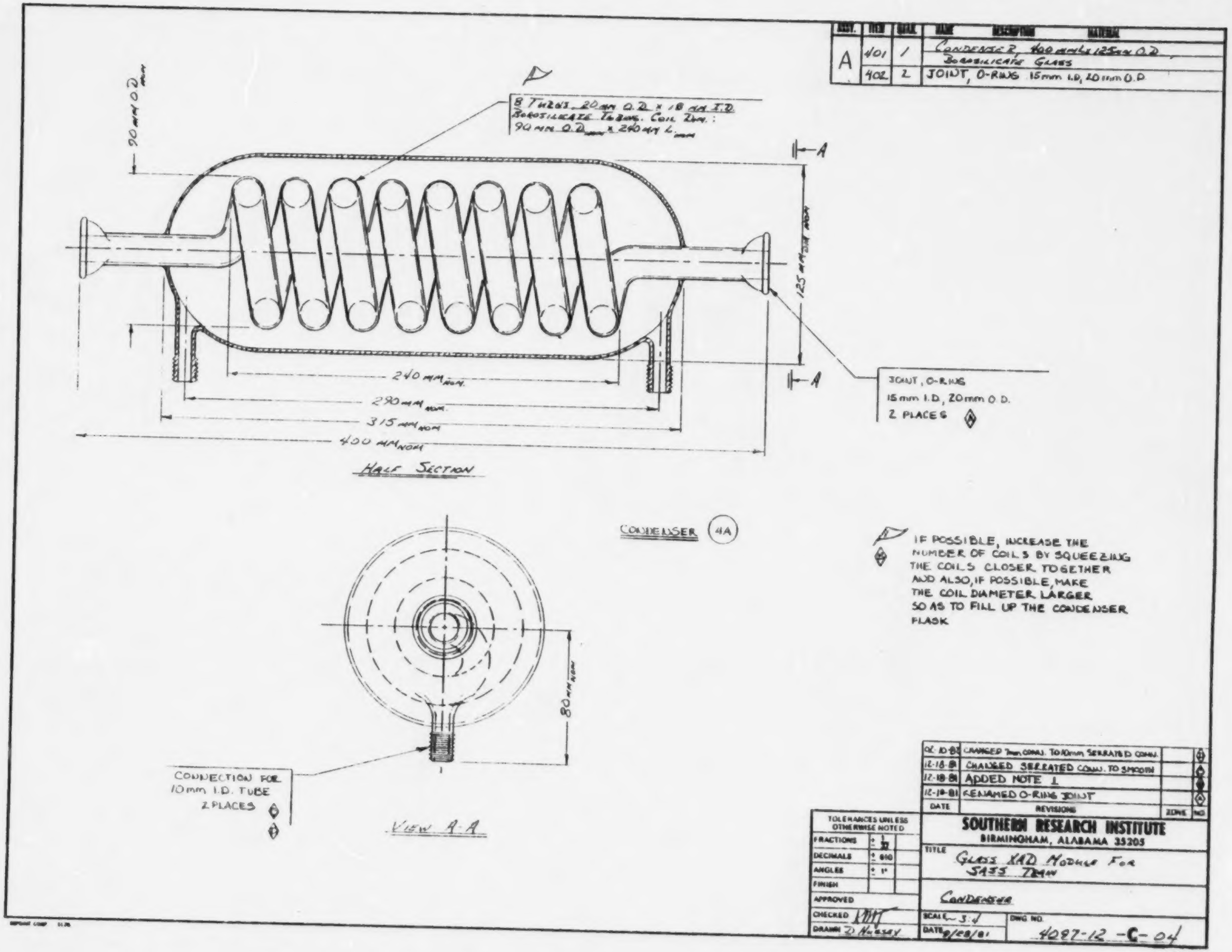
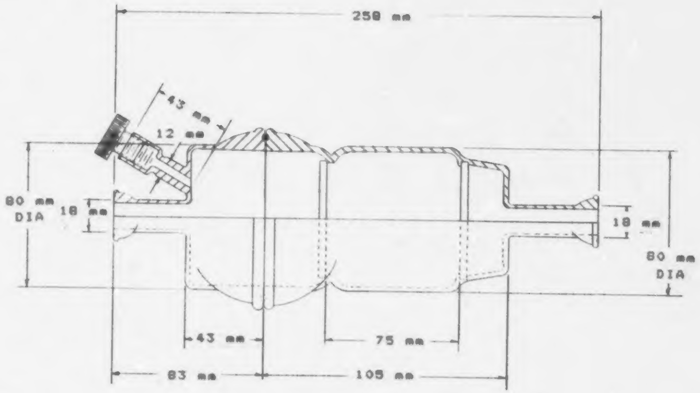

③
⑥
⑤
④
⑦
①
①
①
②
Legend
1 Clamp, Pinch Type, size 28
2 Clamp, Pinch Type, size 102
3 Condenser
4 Condensate Collector
5 Organic Sorbent Cartridge
6 Organic Sorbent Cartridge Cap
7 Condenser Connector Joint
4097-49

Figure 1. Glass module assembly.


ASSY. ITEM QUAN. NAME DESCRIPTION MATERIAL
A 401 1 CONDENSER, 400 mm L x 125 mm O.D., BOROSILICATE GLASS
402 2 JOINT, O-RING 15mm I.D, 20 mm O.D
8 TURNS, 20 mm O.D. x 18 mm I.D. BOROSILICATE TUBING. COIL DIM.: 90 mm O.D. NOM x 240 mm L NOM
90 mm O.D. NOM
125 mm DIA NOM
A
A
240 mm NOM
290 mm NOM
315 mm NOM
400 mm NOM
HALF SECTION
JOINT, O-RING
15mm I.D, 20mm O.D.
2 PLACES
CONDENSER (4A)
IF POSSIBLE, INCREASE THE NUMBER OF COILS BY SQUEEZING THE COILS CLOSER TOGETHER AND ALSO, IF POSSIBLE, MAKE THE COIL DIAMETER LARGER SO AS TO FILL UP THE CONDENSER FLASK
80 mm NOM
CONNECTION FOR 10mm I.D. TUBE 2 PLACES
VIEW A-A
02-10-82 CHANGED 7mm CONN. TO 10mm SERRATED CONN.
12-18-81 CHANGED SERRATED CONN. TO SMOOTH
12-18-81 ADDED NOTE 1
12-18-81 RENAMED O-RING JOINT
DATE REVISIONS ZONE NO
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED
DRAWN D. Hussey
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE GLASS XAD MODULE FOR SASS TRAIN
CONDENSER
SCALE ~ 3:1
DATE 9/28/81
DWG NO. 4097-12-C-04

4097-60

Figure 2. Condenser.


250 mm
43 mm
12 mm
80 mm DIA
10 mm
10 mm
80 mm DIA
43 mm
75 mm
83 mm
105 mm

4097-48

Figure 3. Organic sorbent assembly.

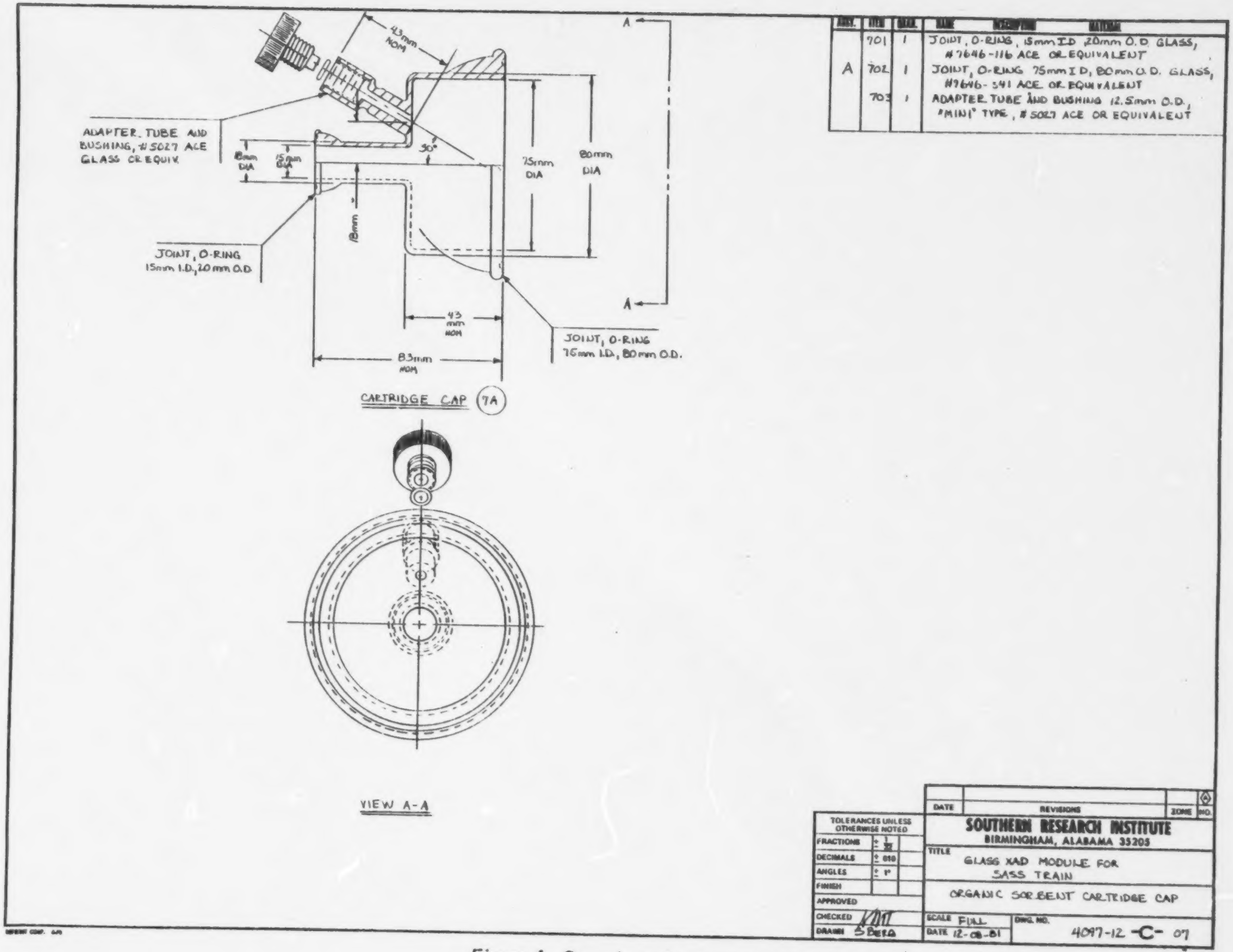
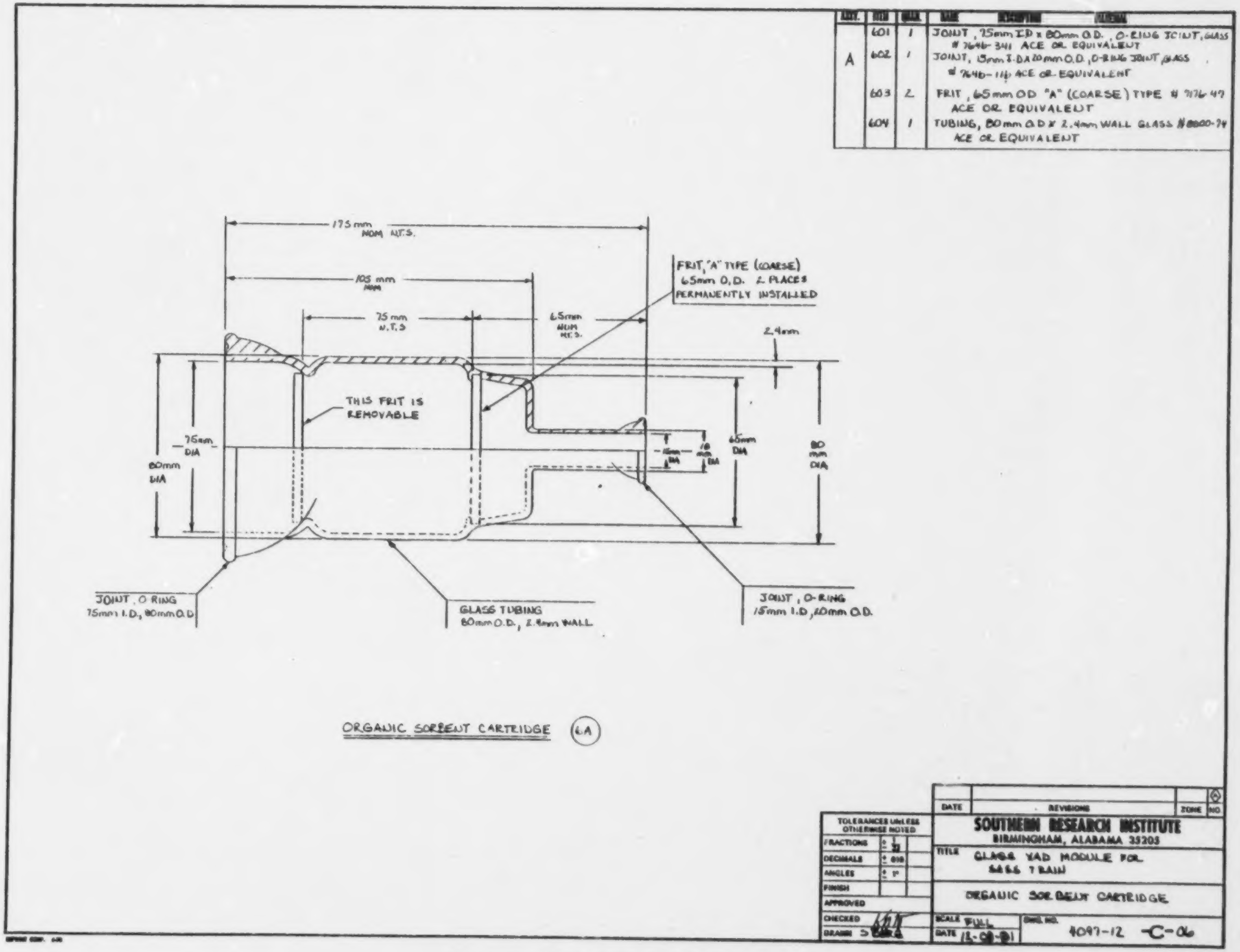

43mm NOM
A
ADAPTER. TUBE AND BUSHING, #5027 ACE GLASS OR EQUIV.
8mm DIA
15mm DIA
30°
75mm DIA
80mm DIA
18mm
JOINT, O-RING 15mm I.D., 20 mm O.D
A
43 mm NOM
83mm NOM
JOINT, O-RING 76mm I.D., 80mm O.D.
CARTRIDGE CAP (7A)
VIEW A-A
701 1 JOINT, O-RING, 15mm ID, 20mm O.D GLASS, #7646-116 ACE OR EQUIVALENT
A 702 1 JOINT, O-RING 75mm I D, 80mm O.D. GLASS, #7646-541 ACE OR EQUIVALENT
703 1 ADAPTER TUBE AND BUSHING 12.5mm O.D., "MINI" TYPE, #5027 ACE OR EQUIVALENT
DATE
REVISIONS
ZONE
NO.
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED KDIT
DRAWN S BERG
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE GLASS XAD MODULE FOR SASS TRAIN
ORGANIC SORBENT CARTRIDGE CAP
SCALE FULL
DATE 12-08-81
DWG. NO. 4097-12 -C- 07

Figure 4. Organic sorbent cartridge cap.

4097-44



A	601	1	JOINT, 75mm I.D x 80mm O.D., O-RING JOINT, GLASS # 7646-341 ACE OR EQUIVALENT
	602	1	JOINT, 15mm I.D x 20mm O.D., O-RING JOINT GLASS # 7646-11 ACE OR EQUIVALENT
	603	2	FRIT, 65mm OD "A" (COARSE) TYPE # 7176-47 ACE OR EQUIVALENT
	604	1	TUBING, 80mm O.D x 2.4mm WALL GLASS #8000-74 ACE OR EQUIVALENT

175 mm NOM N.T.S.
105 mm NOM
75 mm N.T.S
65mm NOM N.T.S.
FRIT, "A" TYPE (COARSE) 65mm O.D. 2 PLACES PERMANENTLY INSTALLED
2.4mm
THIS FRIT IS REMOVABLE
75mm DIA
80mm DIA
15mm DIA
18 mm DIA
65mm DIA
80 mm DIA
JOINT, O RING 75mm I.D., 80mm O.D
GLASS TUBING 80mm O.D., 2.4mm WALL
JOINT, O-RING 15mm I.D, 20mm O.D.
ORGANIC SORBENT CARTRIDGE
6A
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED
DRAWN
DATE
REVISIONS
ZONE
NO.
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE GLASS XAD MODULE FOR SASS TRAIN
ORGANIC SORBENT CARTRIDGE
SCALE FULL
DATE 12-08-81
DWG. NO. 4097-12 -C-06

4097-47

Figure 5. Organic sorbent cartridge.

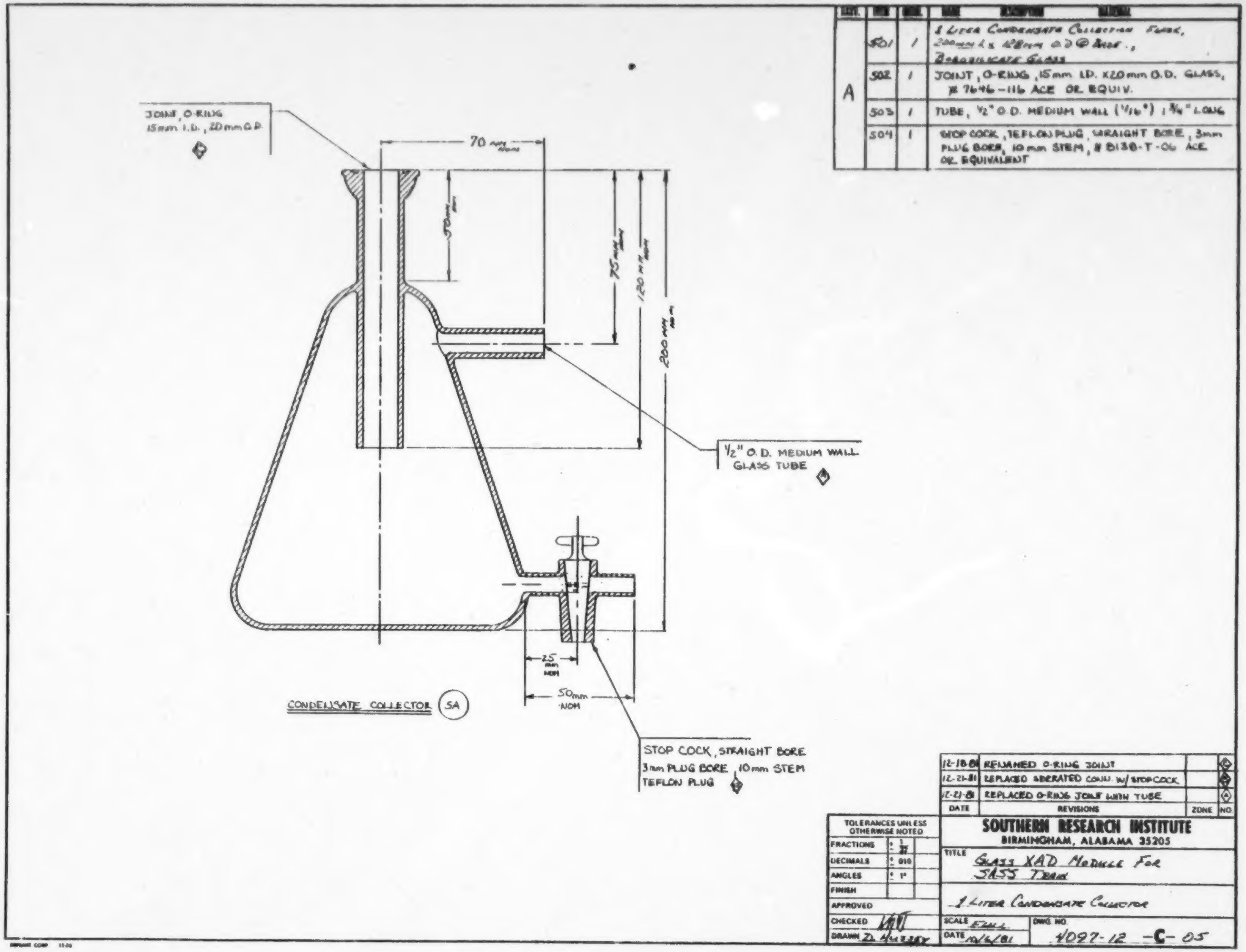

1 Liter Condensate Collection Flask, 200mm L x 128mm O.D @ Base., Borosilicate Glass
A
501
1
502
1
JOINT, O-RING, 15mm I.D. X 20mm O.D. GLASS, # 7646-116 ACE OR EQUIV.
503
1
TUBE, ½" O.D. MEDIUM WALL (1/16") 1¾" LONG
504
1
STOP COCK, TEFLON PLUG, STRAIGHT BORE, 3mm PLUG BORE, 10mm STEM, # 8138-T-06 ACE OR EQUIVALENT
JOINT, O-RING 15mm I.D., 20mm O.D.
70 mm nom
50 mm
75 mm nom
120 mm nom
200 mm nom
½" O.D. MEDIUM WALL GLASS TUBE
25 mm nom
50mm nom
CONDENSATE COLLECTOR
5A
STOP COCK, STRAIGHT BORE 3mm PLUG BORE 10mm STEM TEFLON PLUG
12-18-81 RENAMED O-RING JOINT
12-21-81 REPLACED SERRATED CONN. W/ STOPCOCK
12-21-81 REPLACED O-RING JOINT WITH TUBE
DATE
REVISIONS
ZONE
NO
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED
DRAWN D. Murray
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE Glass XAD Module For SASS Train
1 Liter Condensate Collector
SCALE Full
DATE 10/6/81
DWG NO. 4097-12 -C- 05

Figure 6. Condensate collector.

4097-46

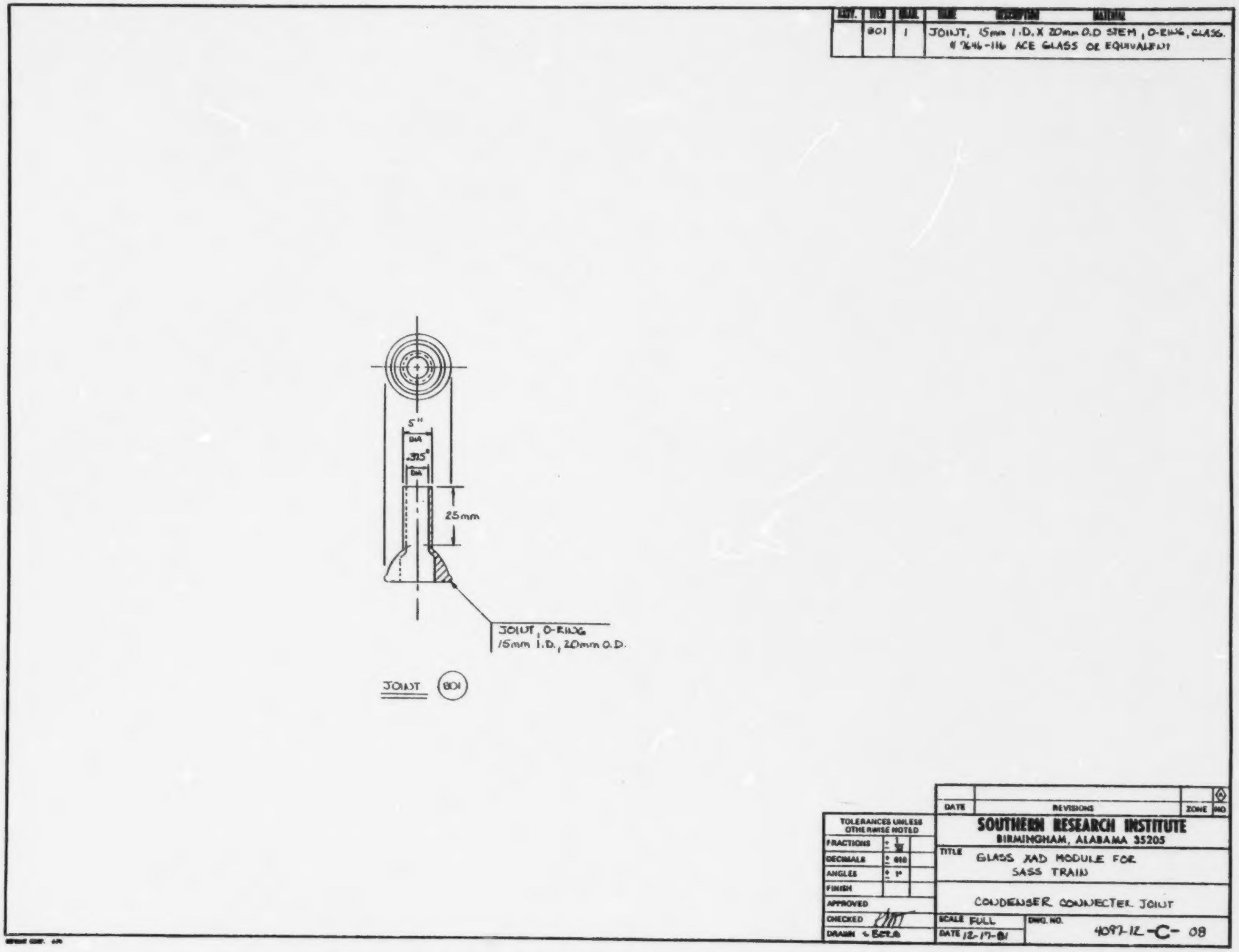

801
1
JOINT, 15mm I.D. X 20mm O.D STEM, O-RING, GLASS.
# 7646-116 ACE GLASS OR EQUIVALENT
5"
DIA
.315"
DIA
25mm
JOINT, O-RING
15mm I.D., 20mm O.D.
JOINT
801
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED
DRAWN S. BERA
DATE
REVISIONS
ZONE
NO
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE GLASS XAD MODULE FOR SASS TRAIN
CONDENSER CONNECTER JOINT
SCALE FULL
DATE 12-17-81
DWG. NO. 4097-12-C-08

Figure 7. Condenser connector joint.

4097-45

70 mm, the same as in the existing SASS cartridge.

Liquid water which forms in the condenser drips through the sorbent bed into the condensate collector (Figure 6). The gas stream also passes through the collector and exits through a 1/2" sidearm. All glass pieces, including the mating halves of the sorbent cartridge assembly, are connected using clamped o-ring type connectors such as on the inlet adaptor shown in Figure 7.

In spite of the reports of PEDCo personnel that their coil condenser adequately cooled the gas stream, we found indications that our condenser might not have adequate cooling capacity even though it was a copy of the PEDCo device. In order to assure adequate gas cooling for the sorbent module, a second condenser of a different design was fabricated. This piece, shown in Figure 8, is of thin film, concentric cylinder design similar to the conventional Davies condensor. The design incorporates inner and outer water jackets which can have different cooling water supplies. This condenser was found not to function as well as the coiled type design, but was able to serve as an adequate "pre-chiller" for the gas stream when used in series with the coiled tube condenser.

In order to support and protect the glassware in this train, a wooden stand is used (Figure 9). A movable support piece (Figure 10) allows the stand to accept one or both condensers in series.

The cooling control for the module is shown in Figure 11. This unit operates basically like the corresponding SASS module. The cooled gas temperatures is sensed by a thermistor sensor in the gas stream in the sorbent cartridge. A single setpoint, proportioning controller (LOVE Controls Model 49) drives a 3-way brass solenoid valve which controls water temperature by alternately cycling cooling water through a chiller loop or around it. Cooling water is drawn from an insulated reservoir (2 gal. Igloo model water cooler) by a centrifugal pump (Sargent Welch No. S71552) and passes through the condenser water jacket(s). After exiting, the water passes into the 3-way solenoid valve, where it passes back to the reservoir either directly or through heat exchanger coils mounted in the impinger ice bath (Figure 12). In order to allow better heat transfer in the coils, the diameter and length of the coils was increased over the current SASS module. In addition, the present uninsulated impinger bath was replaced by an insulated commercial ice chest (Figure 12).

When the thin-film type cooler is used with recirculated ice water in the inner jacket it is possible to start the sampling as in the existing SASS module. However, it is preferable to cool the water in the reservoir to a temperature which experience shows to give the appropriate gas temperature. This may be done on the cooling module control box by placing the "SET UP/RUN" control mode switch in "SET UP" position and setting the desired cooling water temperature in the temperature controller. In this mode, the cooling cycle is controlled by a second thermistor sensor in the reservoir. After the

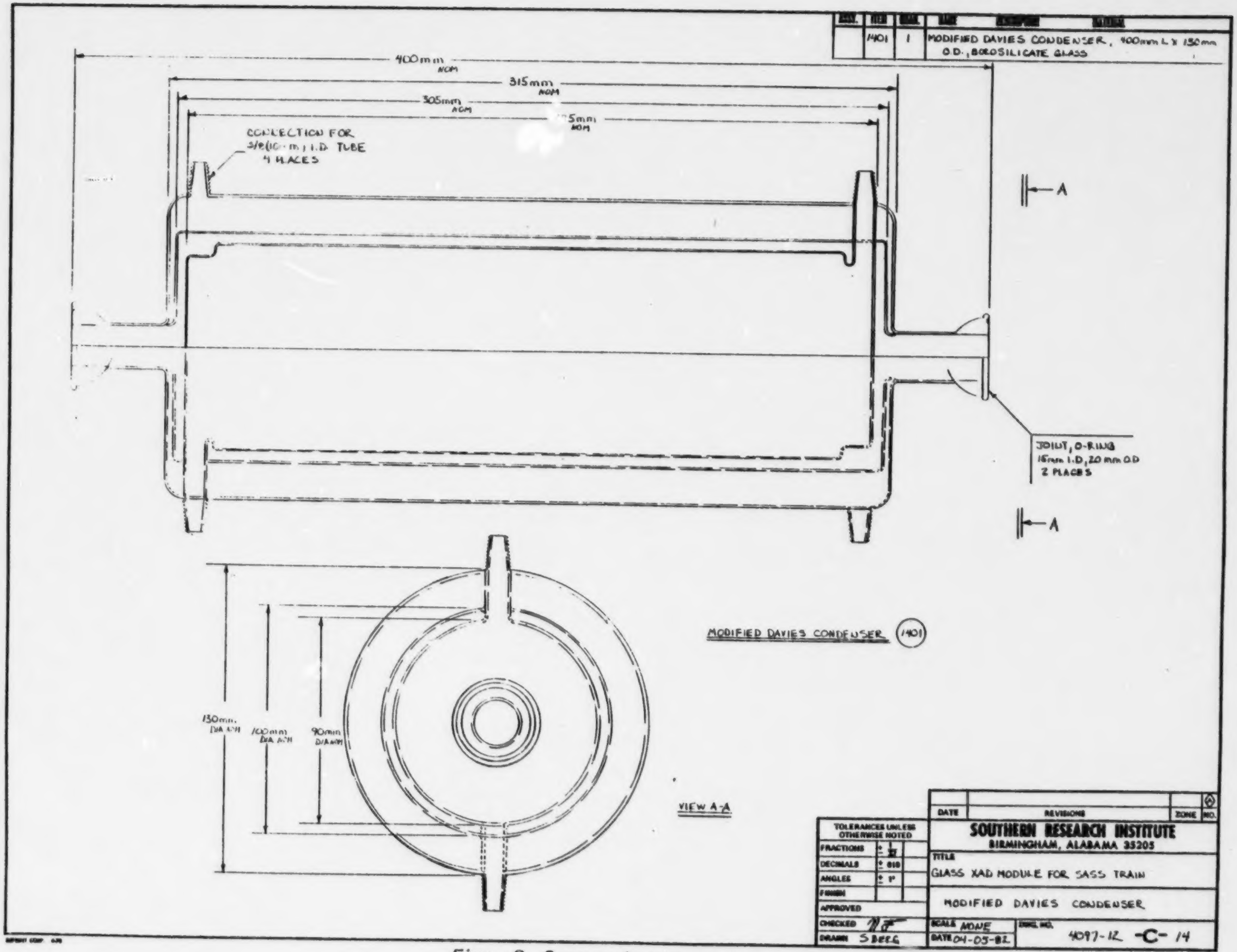

1401
1
MODIFIED DAVIES CONDENSER, 400mm L x 150mm O.D., BOROSILICATE GLASS
400mm NOM
315mm NOM
305mm NOM
5mm NOM
CONNECTION FOR 3/8(10·m) I.D TUBE 4 PLACES
A
A
JOINT, O-RING 16mm I.D, 20mm O.D 2 PLACES
MODIFIED DAVIES CONDENSER
1401
130mm DIA NOM
100mm DIA NOM
90mm DIA NOM
VIEW A-A
DATE
REVISIONS
ZONE
NO.
TOLERANCES UNLESS OTHERWISE NOTED
FRACTIONS ± 1/32
DECIMALS ± .010
ANGLES ± 1°
FINISH
APPROVED
CHECKED
DRAWN S BERG
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA 35205
TITLE
GLASS XAD MODULE FOR SASS TRAIN
MODIFIED DAVIES CONDENSER
SCALE NONE
DATE 04-05-82
DWG. NO. 4097-12 -C- 14

Figure 8. Concentric tube condenser.

4097-61

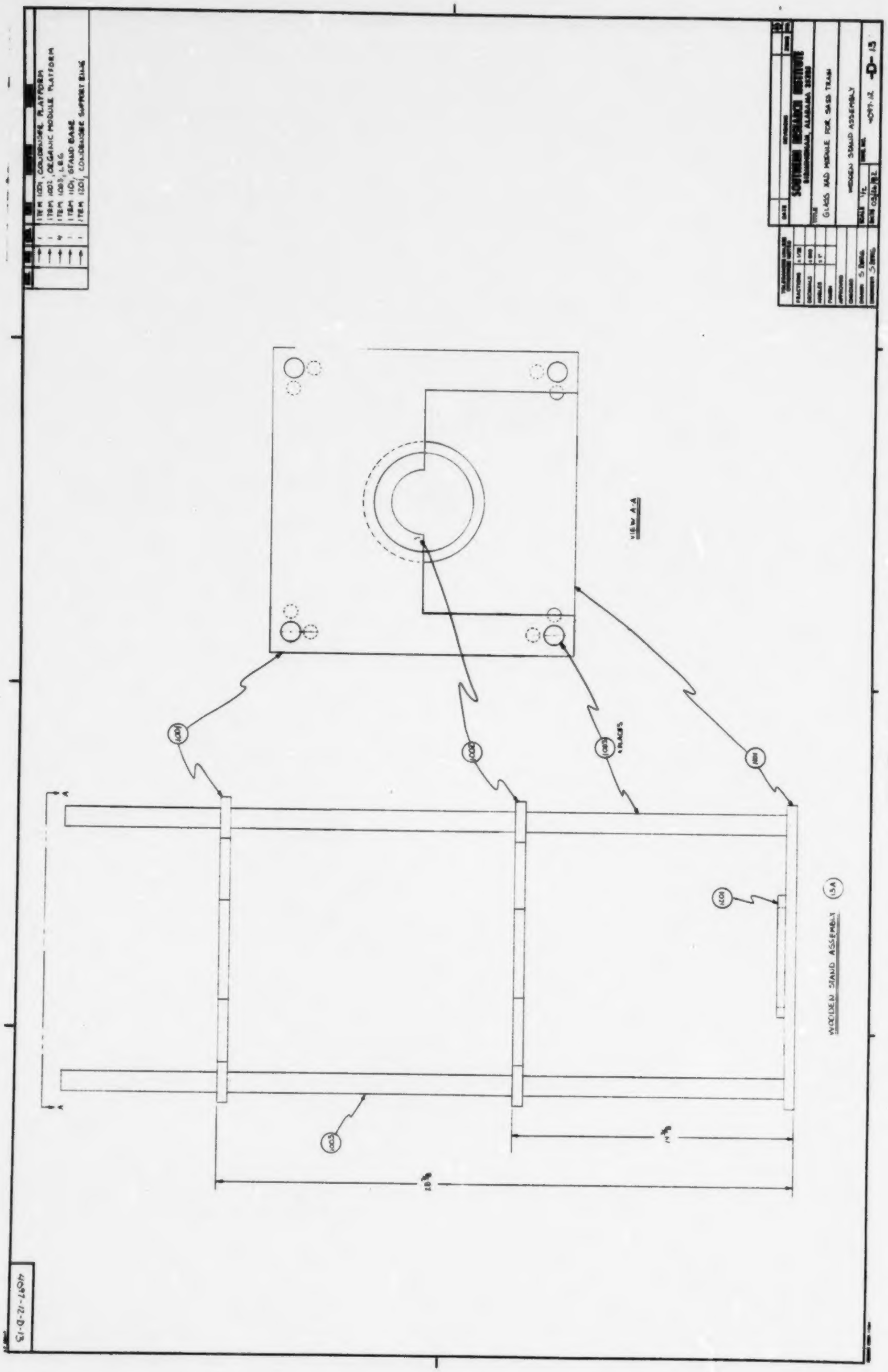

ITEM 1001, CONDENSER PLATFORM
ITEM 1002, ORGANIC MODULE PLATFORM
ITEM 1003, LEG
ITEM 1101, STAND BASE
ITEM 1201, CONDENSER SUPPORT RING
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM, ALABAMA
GLASS XAD MODULE FOR SASS TRAIN
WOODEN STAND ASSEMBLY
4097-12
D
13
S. EWING
VIEW A-A
1001
1002
1003
4 PLACES
1101
1201
1003
WOODEN STAND ASSEMBLY
13A
4097-12-D-13
4097-62

Figure 9. Wooden stand assembly.

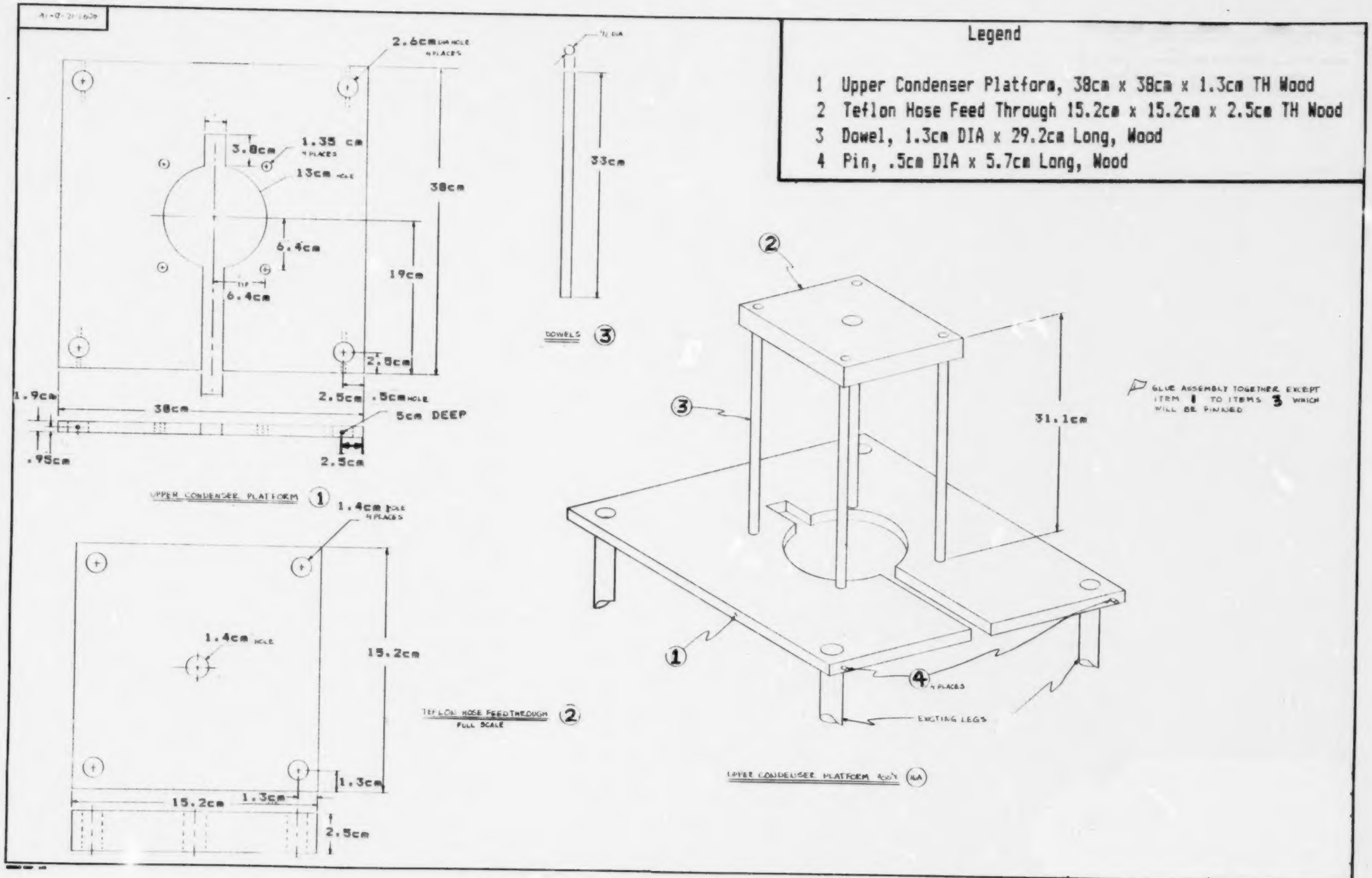

Legend
1 Upper Condenser Platform, 38cm x 38cm x 1.3cm TH Wood
2 Teflon Hose Feed Through 15.2cm x 15.2cm x 2.5cm TH Wood
3 Dowel, 1.3cm DIA x 29.2cm Long, Wood
4 Pin, .5cm DIA x 5.7cm Long, Wood
2.6cm DIA HOLE 4 PLACES
3.8cm
1.35 cm 4 PLACES
13cm HOLE
38cm
6.4cm
19cm
6.4cm
2.8cm
1.9cm
38cm
2.5cm
.5cm HOLE
5cm DEEP
.95cm
2.5cm
UPPER CONDENSER PLATFORM ①
1.4cm HOLE 4 PLACES
1.4cm HOLE
15.2cm
1.3cm
15.2cm
1.3cm
2.5cm
TEFLON HOSE FEEDTHROUGH ②
FULL SCALE
33cm
DOWELS ③
②
③
①
④ 4 PLACES
31.1cm
GLUE ASSEMBLY TOGETHER EXCEPT ITEM 1 TO ITEMS 3 WHICH WILL BE PINNED
EXISTING LEGS
UPPER CONDENSER PLATFORM ASS'Y

Figure 10. Upper condenser support for stand.

4097-53

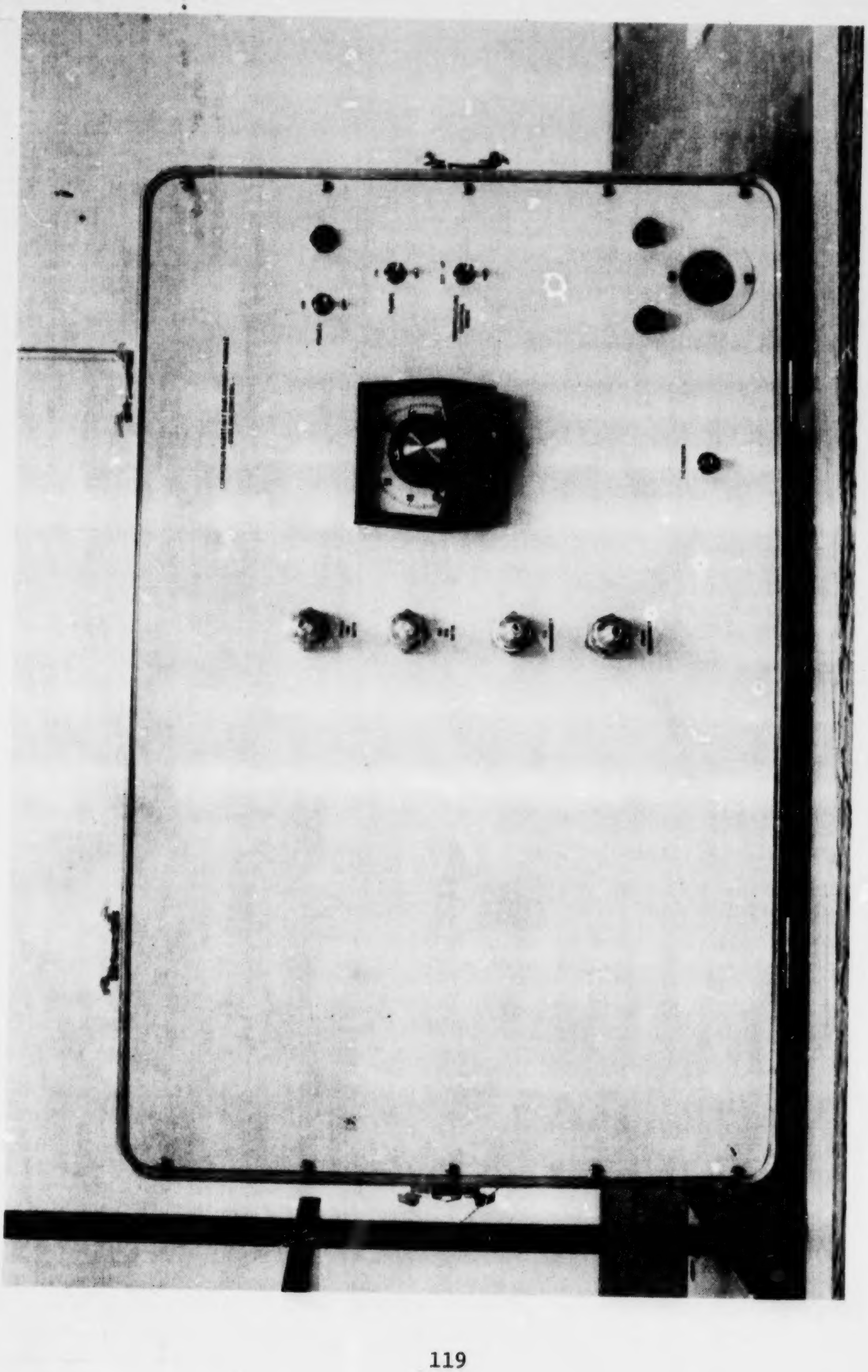


Figure 11. Temperature control module.

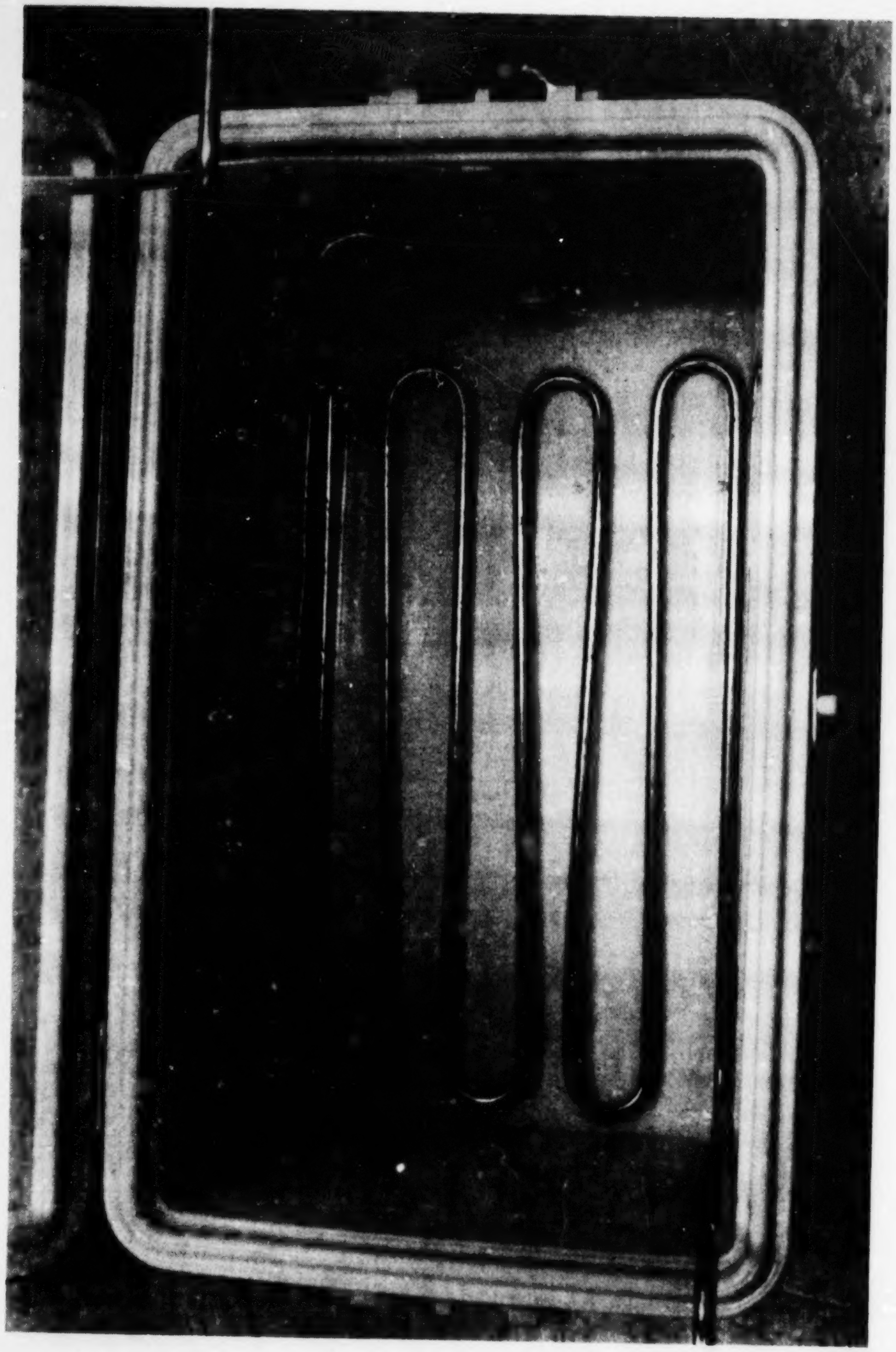


Figure 12 Impinger bath and heat exchanger coils

desired reservoir temperature has been reached, the mode switch can be returned to the RUN position, the desired air temperature (68°F) set on the controller, and the SASS train started as usual.

The assembled glass module is shown in Figure 13. The stand was designed to give some degree of protection as well as support to the glassware. In order to protect the glassware during shipping, a foam-padded trunk is used. Figure 14 shows the trunk with the glassware placed for travel.

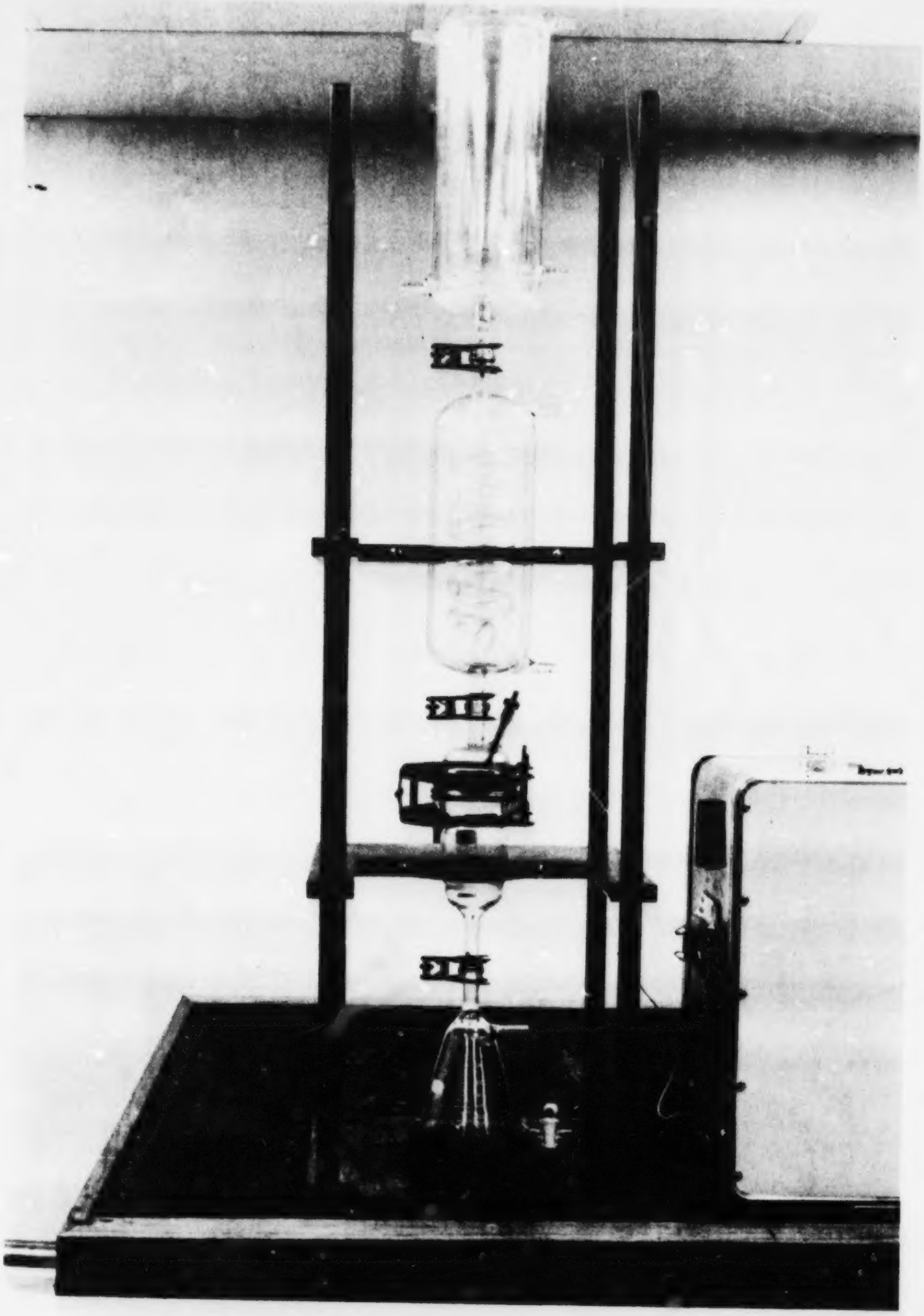


Figure 13. Assembled organic module and stand

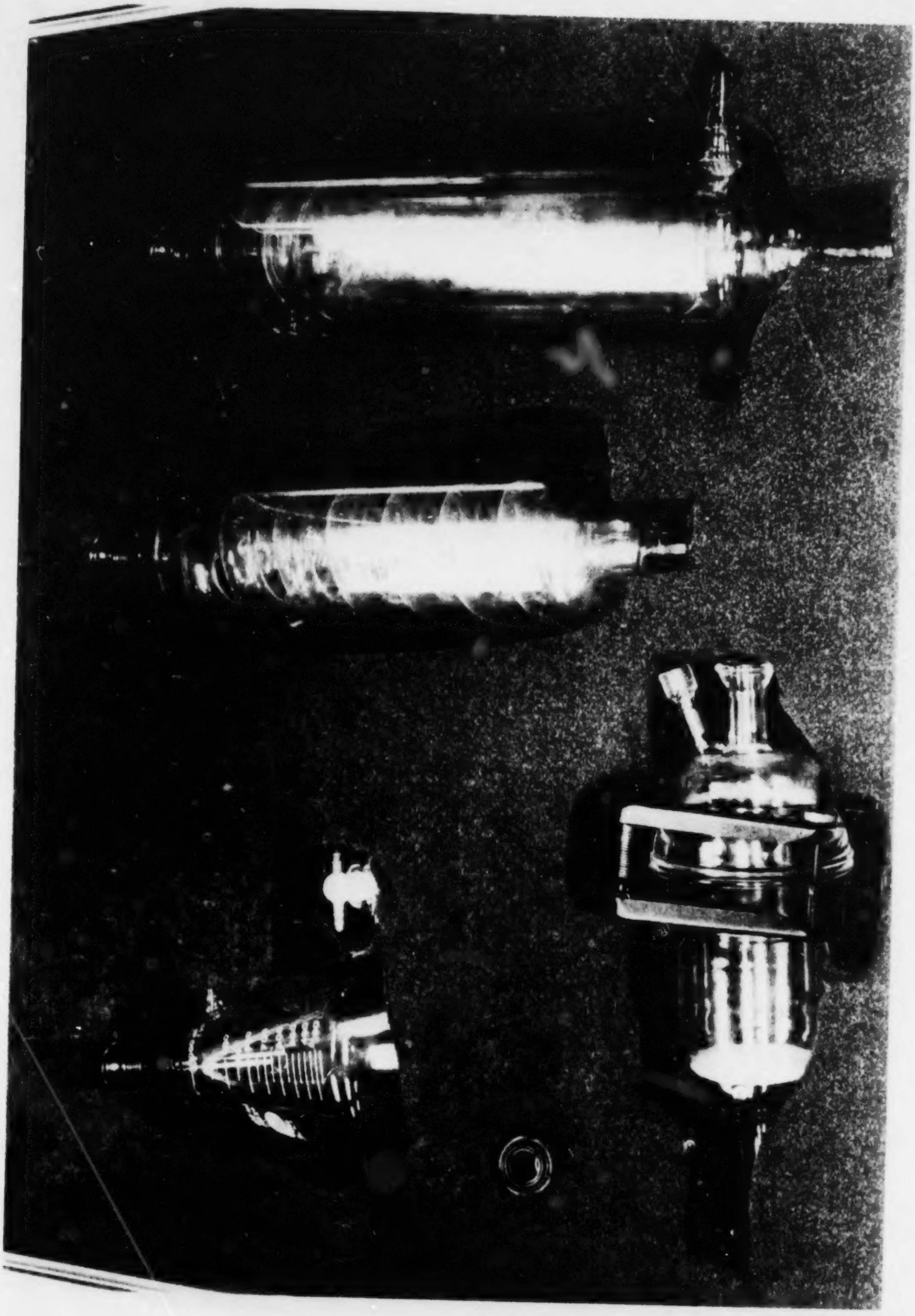


Figure 14 Glassware in shipping case

REFERENCES

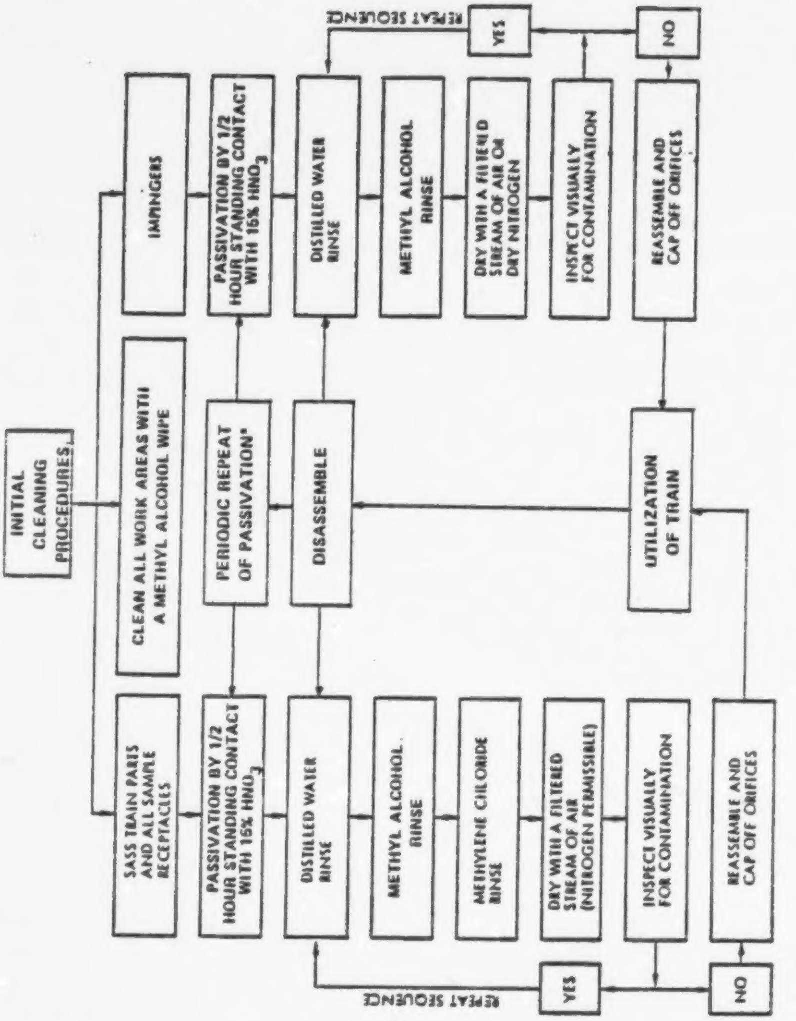
1. Blake, D. Source Assessment Sampling System: Design and Development. EPA-600/7-78-018 PB-279757, U.S. Environment Protection Agency, Research Triangle Park, NC, 1978. 221 pp.

2. SASS User Survey. Prepared by the Acurex Corporation, Energy & Environmental Division, 485 Clyde Avenue, Mountain View, California 94042, under EPA Contract Number 68-02-2678, William B. Kuykendal, Project Officer. Prepared for the Industrial Environmental Research Laboratory, Environmental Protection Agency, Research Triangle Park, North Carolina 27711. November 1978.

3. Williams, J.R. and W.S. Morris. Conceptual Design Study for the Source Assessment Sampling System Organic Module, Acurex Final Report 78-314. Prepared by the Acurex Corporation, Energy & Environmental Division, 485 Clyde Avenue, Mountain View, California 94042, under EPA Contract Number 68-02-2678. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. December 1978.

APPENDIX E

SASS CLEANING PROCEDURES


INITIAL CLEANING PROCEDURES
SASS TRAIN PARTS AND ALL SAMPLE RECEPTACLES
CLEAN ALL WORK AREAS WITH A METHYL ALCOHOL WIPE
IMPINGERS
PASSIVATION BY 1/2 HOUR STANDING CONTACT WITH 15% HNO3
PERIODIC REPEAT OF PASSIVATION*
PASSIVATION BY 1/2 HOUR STANDING CONTACT WITH 15% HNO3
DISTILLED WATER RINSE
DISASSEMBLE
DISTILLED WATER RINSE
METHYL ALCOHOL RINSE
METHYL ALCOHOL RINSE
METHYLENE CHLORIDE RINSE
DRY WITH A FILTERED STREAM OF AIR (NITROGEN PERMISSIBLE)
DRY WITH A FILTERED STREAM OF AIR OR DRY NITROGEN
INSPECT VISUALLY FOR CONTAMINATION
INSPECT VISUALLY FOR CONTAMINATION
REASSEMBLE AND CAP OFF ORIFICES
UTILIZATION OF TRAIN
REASSEMBLE AND CAP OFF ORIFICES
YES
NO
REPEAT SEQUENCE
YES
NO
REPEAT SEQUENCE

*Refer to text for passivation time schedule.

SASS Cleaning Procedures

Source: "IERL-RTP Procedures Manual: Level 1 Environmental Assessment (Second Ed.) EPA-600/7-78-201